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Broadening our Concepts of Universal Access

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Abstract: The universal accessibility movement has focused on solutions for people with physical limitations. While this work has helped bring about positive initiatives for this population, physical disabilities are just one of the many life situations that can complicate people's ability to fully participate in an information economy and society. Other factors affecting accessibility include poverty, illiteracy, and social isolation. This paper explores how the universal accessibility movement can expand its efforts to reach other diverse populations. We discuss four sets of resources -- physical, digital, human, and social -- that are critical for enabling people to use information and communication technology, and provide some examples of how these resources can help people access, adapt, and create knowledge.

Keywords: universal access; accessibility; communication; education

Introduction

As Manuel Castells (1998) notes, the ability to access, use, and adapt information and communication technologies is "the critical factor in generating and accessing wealth, power, and knowledge in our time" (p. 92). Yet it is an ability that is shared unequally in today's world, both across and within nations. How then can we better extend participation in global knowledge networks?

In every country around the world, those with disabilities have faced especially restricted access to information technology. Those with vision limitations are restricted in their ability to read text-based communication, or understand the images or videos that accompany text. Those with hearing disabilities are shut out of the critical auditory content of videos for education, news, and entertainment. Other physical or cognitive disabilities can affect people's capability of operating a mouse, keyboard, or keypad.

Starting in 1960s, when architect Selwyn Goldsmith published *Designing for the Disabled* (1963) and created the dropped curb that could be used by wheelchairs, a movement has grown demanding that buildings, products, and environments be designed so as to be accessible to the disabled. Following in the footsteps of this universal design movement, a "universal accessibility" movement later emerged to demand that computer hardware, software, and interfaces also be made accessible to the disabled. Many positive initiatives have emerged from this movement, including increased closed captioning of videos, text-to-speech and voice-over tools, dictation features, and zoom magnification of screen content.

Though these features are inconsistently provided, this movement for universal accessibility has undoubtedly helped make digital media more available to those with disabilities. At the same time, physical disabilities are only one of the many factors that inhibit people from full access to technology. According to the most recent data, due to poverty, social isolation, or other reasons, some two-thirds of the people in the world do not use the Internet (Miniwatts Group, 2014). And, among those who use it, many lack the reading ability or language skills to take full advantage of online content.

How then can the notion of universal accessibility be extended to address the numerous factors, in addition to physical or cognitive disability, that hinder people's access?

First, it is crucial to consider what "access" entails. In earlier work, the authors have discussed four sets of resources that are critical for enabling people to use information and communication technology to access, adapt, and create knowledge: physical resources, digital resources, human resources, and social resources (Warschauer, 2002; Warschauer, 2003c). This is a mutually reinforcing process, as the availability of these resources helps people to make effective use of new technology, and use of new technology can also extend people's access to these resources (see Figure 1).

The universal accessibility movement has restricted itself almost entirely to the first two of these sets of resources. It is valuable to consider what more needs to be done in these two areas, as well as how the latter two areas should be addressed, to better strive for truly universal access.

Physical Resources

Physical resources refer to the hardware and telecommunication links that underlie access to online information and networking. Advocates of overcoming the so-called “digital divide" have placed great effort on making physical resources more available. Perhaps the best-known initiative in this regard is the One Laptop per Child (OLPC) program, which launched in 2005 with the goal of creating an inexpensive laptop computer and making it available to hundreds of millions of children in low-income countries. OLPC has distributed about 1.5 million computers, rather than the 150 million that it initially set its sights on, and has run into countless problems from breakages of equipment to rejection by teachers to limited educational impact on students (Kraemer, Dedrick, & Sharma, 2009; Warschauer & Ames, 2010; Warschauer, Cotten, & Ames, 2012). Though there were extensive problems with both OLPC’s hardware (which broke down quickly and was difficult to repair) and its implementation model (which downplayed the human and social factors necessary to improve learning with computers), even from the simple point of view of extending physical access its approach was highly flawed. Though computers have steadily fallen in price, they are still simply unaffordable on an individual basis in impoverished countries (see discussion in Warschauer and Ames, 2010). Truly low-income countries could only provide computers to all their children if they somehow were able to divert almost their entire educational budget for that purpose. Universal accessibility, as regards to physical infrastructure, thus needs instead to focus on different approaches, such as easing people’s ownership of more affordable devices, such as mobile phones (Donner, 2008); providing opportunities for access to shared computers, whether in computer laboratories, classrooms, or community centers (Pal, Patra, Nedevschi, Plauche, & Pawar, 2009; James, 2011); and creating more competitive markets and thus lower prices for Wi-Fi and cellular access (Warschauer, 2003).

One promising project based on more affordable devices is the Worldreader program, which uses a combination of e-readers (Fowler & Bariyo, 2012) and cell phone applications (Olson, 2013) to promote literacy among children in Africa. Content provided includes material from local textbooks and storybooks in Africa, as well as literature from African authors. The organization conducts extensive monitoring and evaluation and claims significant benefits for mother tongue literacy development, though independent peer-reviewed research on the project is not yet available.

Digital Resources

Digital resources, which involve the types of content available online and how that content is presented, is the area in which the movement for universal accessibility has principally focused its efforts. This is also the area in which the links between accessibility for the disabled and accessibility for the broader population potentially overlap the most, since many steps that provide support for those with disabilities may also be of benefit to those with limited literacy.

Anderson-Inman, director of the National Center for Supported eText at the University of Oregon in the U.S., has nicely summarized the ways that technological modifications can help make texts accessible to the broadest range of readers, including those with physical disabilities, cognitive disabilities, struggling readers, and second language learners (Anderson-Inman & Horney, 2007; see Figure 2).

Many of these modifications are very promising. One area that has been investigated is visual-syntactic text formatting (VSTF; Walker, Schloss, Fletcher, Vogel,

& Walker, 2005; Warschauer, Park, & Walker, 2011). Since the human eye span can only take in 9-15 characters at a time, reading traditional block text involves many shifts of glance and back and forth eye movements, especially at phrase boundaries (see Walker et al., 2007). This reading process can be quite challenging for those with restricted vision or cognitive disabilities, as well as for those with low reading ability or limited syntactical knowledge of the text they are reading. VSTF uses natural language processing to automatically parse texts and then re-present them in a cascaded format that better matches the way the eye and brain process information (see Figure 3). Research suggests that reading with VSTF facilitates comprehension and language development, especially for second language learners (Warschauer et al., 2011).

One strong advantage of VSTF is that it makes texts more accessible without simplifying their content. That allows people to read and comprehend more difficult original texts than they would otherwise have been able to. Research suggests that the learning gains transfer back so that people who read with VSTF regularly over a course of a year also improve their ability to read in traditional formatting (Walker et al., 2005). This fulfills an important principle of universal design for learning: that design should not only enhance learners' access to immediate content, but should also strengthen people's capacity for further learning in the future (Rose & Meyer, 2002).

The Center for Applied Special Technology (CAST) has also developed designs that make educational content more accessible to readers with limited literacy or language abilities. In an earlier initiative, multimodal glosses attuned to the particular vocabulary needs of English language learners helped improve reading comprehension for all (Proctor et al., 2011). In a new initiative, CAST is collaborating with Vanderbilt

University to build a new reading platform, so-called Udio, that combines textual modification, illustration, and collaborative tools targeted at students with diverse reading abilities (Hasselbring, 2014).

Bearing in mind the earlier discussion on the physical infrastructure in low-income countries around the world, it is also very important to develop the means for making these kinds of tools available for cell phone platforms and low-bandwidth contexts. The best solutions are those that involve maximal flexibility for changing presentational styles according to device, connection speed, and user preference.

Finally, though making content more accessible in English is an important priority, given how much of the world's economic and scholarly affairs are conducted in that language, continuing to develop online content in multiple languages is also a priority for the many billions who speak other languages. Indeed, research suggests that even for those learning English as a second language, literacy in their first language is correlated with long-term academic development (Cummins, 1991), and thus should be promoted to the greatest extent possible.

Human Resources

In the long run, human capital is the most critical element for accessing and creating knowledge with technology. The approaches discussed above can aid in human capital development by making educational content more accessible online. How else can new technologies enhance this effort?

Again, it is helpful to look at the experiences of OLPC, which has sought to address educational challenges through large-scale distribution of computers to children. Providing computers to children who otherwise would not have been able to use them can bring some cognitive benefits, as demonstrated in studies in both Romania (Malamud & Pop-Eleches, 2010) and Peru (Beuermann, Cristia, Cruz-Aguayo, Cueto, & Ofer, 2013). However, those same studies, as well as others (de Melo, Machado, Alfonso, & Viera, 2013; Vigdor, Ladd, & Martinez, 2014) demonstrate that simply supplying computers has no positive impact on students' academic achievement in reading, math, or other areas.

A comparative case study was recently conducted by the first author in three school districts in the United States, all of which used inexpensive netbook computers and open source software (Warschauer, Zheng, Niiya, Cotten, & Farkas, 2014). All three sought to improve technological access and academic achievement among low-income learners, underrepresented minorities, and English language learners. One of the districts used the OLPC approach, which basically involved distributing computers to children. The other two districts used more integrative approaches, which combined distribution of computers to children with teachers' professional development, curriculum development, attention to pedagogy, and technical support. The OLPC program was the fastest to be implemented, but it also quickly failed. The computers were seldom integrated into instruction and brought little measurable benefit; the program was ended in less than three years. In the other two districts that used a more integrative approach, implementation was slower, due in part to the necessity to fund other expenses besides hardware purchase (e.g., teacher training) and in part to the desire to test out approaches and then build on successful ones. Nevertheless, the programs continued longer and gradually expanded; analysis of standardized test scores also showed that both programs significantly improved the reading and writing outcomes of low-income and underrepresented students, and thus fulfilled the goal of helping bridge educational gaps (Zheng, Warschauer, & Farkas, 2013).

An Internet-connected computer is one of the most powerful tools for knowledge production ever imagined, yet it is also one of the most powerful causes for distraction from learning. For that reason, educational technology often has an amplifying effect. Schools that are already well-structured to support student learning can further improve their work through technology; whereas schools without those structures in place will see money and efforts dissipated, or even contributing to further distraction and negative results (Warschauer, 2006, 2008; Russell & Abrams, 2004). This does not mean that efforts to improve low-performing schools with technology should be abandoned, but rather that the provision of equipment needs to be part of broader educational reform efforts involving attention to pedagogy, curriculum, and assessment (Warschauer & Matuchniak, 2010).

For schools that are not functioning well at all, other technology-based interventions than provision of computers may be more effective. For example, in rural Indian schools with large teacher absenteeism, merely tracking teachers' attendance by providing digital cameras with date and time stamps and requiring a daily photo of the teacher at school cut teacher absences almost in half and led to a 40-percent increase in students' graduation rates (Duflo & Hanna, 2005; Warschauer, 2012). This is a much better use of technology than providing computers that are unlikely to get used well.

Social Resources

The final set of resources required for effective use of technology are social, involving the norms, expectations, assistance, and mentoring that come from family members, friends, and community (Warschauer, 2003a). The value of social mobilization and support is made clear by Kling, who contrasts what he characterizes as a standard tool model of technology versus a sociotechnical model (Kling, 1999; Kling & Lamb, 2001; Kling, 2000). From the first perspective, as summarized earlier (Warschauer, 2011), technology is a tool to be passed out, implementations are one-shot, technological effects are direct and immediate, politics are irrelevant, social effects are benign, contexts are simple, knowledge and expertise are easily made explicit, and infrastructures are fully supportive. In fact, though, as Kling and others have demonstrated through extensive research in schools, governments, and businesses, technology is more of a sociotechnical network than a tool, implementations are ongoing, effects are often indirect and involve multiple timescales, politics are central, social repercussions are unpredictable, contexts are highly complex, knowledge and expertise are inherently tacit or implicit, and much additional skill and work are needed to make infrastructures function.

How this plays out can be seen in another comparative case study carried out, this time in Mexico (Cervantes, Warschauer, Nardi, & Sambasivan, 2011). Once again several schools were compared that were using low-cost netbook computers, in this case either the XO computers of the OLPC program or ClassmatePC laptops that were part of Intel's World Ahead program. The schools faced numerous obstacles in implementing technology-enhanced instruction, ranging from insufficient power outlets to poorly trained teachers. It was found that the most important factor affecting implementation was not the type of laptop used, nor the socio-economic status of the school and its students, nor even whether computers were used individually or shared, but rather the ways that social relations were mobilized in support of the laptop programs. This ranged from frequent dialogue between technology coordinators and teachers to assist improved computer use, lobbying efforts to school district authorities to provide infrastructural support, and engaging parents in fund-raising efforts. Schools with strong social structures that could mobilize community social support succeeded; those that did not failed. Prior research conducted in US schools shows the same results (Warschauer, 2007).

Another example is seen in the Hole in the Wall project launched in India, which placed computers in kiosks to reach low-income and marginalized youth. Though the program showed some initial benefits (Mitra, 1999; Mitra & Rana, 2001; Mitra, 2005), initial attempts to place kiosks in unsupervised areas devoid of social support proved difficult to sustain (Warschauer, 2003b). The most lasting effects occurred when the projects shifted kiosks to places offering social support for learning, such as schools (Arora, 2010).

The field of community informatics holds many lessons on the role of social mobilization for technology-enhanced development (Gurstein, 2000; Keeble & Loader, 2001). These lessons stress that social capital is created and leveraged by building the strongest possible coalitions and networks in support of a community's goals, using technology projects as a focal point and organizing tool.

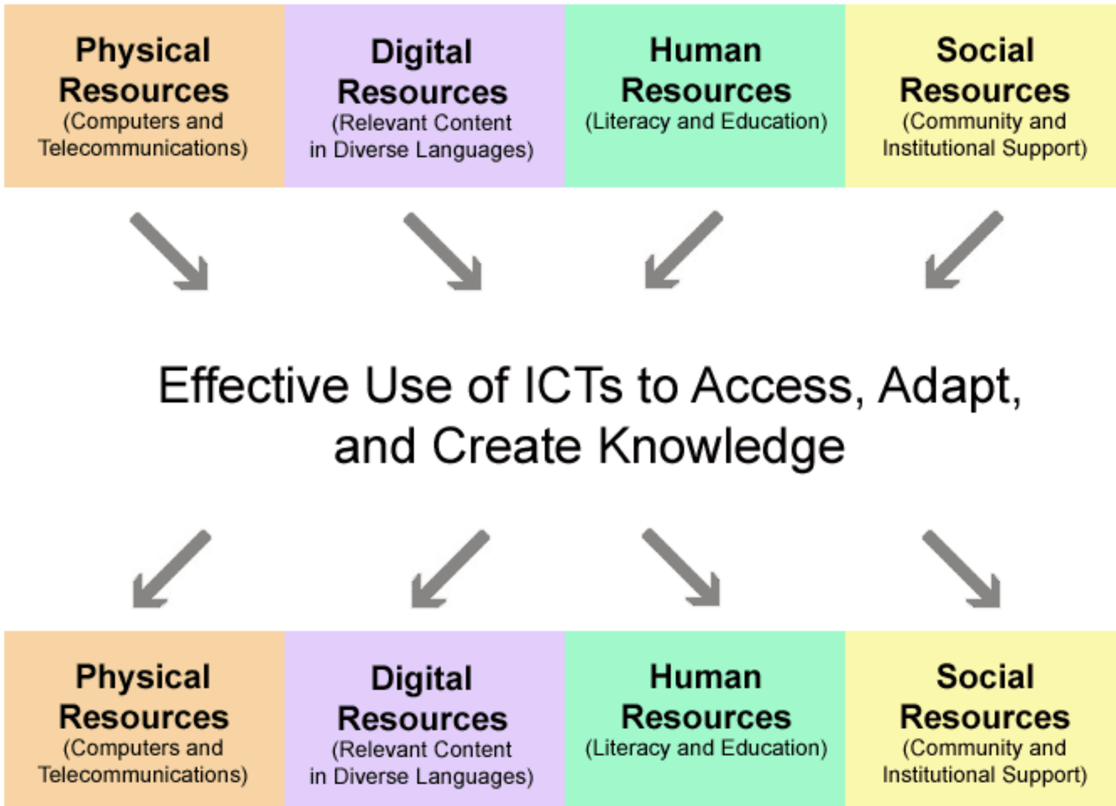
Finally, although these resources are listed separately, they obviously overlap and interact with each other. Among them, the social resources are particularly important, as they serve as a way of mobilizing how the remaining resources are structured and deployed.

Conclusion

Physical disabilities are just one of the many life situations that can complicate people's ability to fully participate in an information economy and society. Other factors include poverty, illiteracy, and social isolation. Indeed, there is an especially high correlation between physical disability and these other factors, both because disability can hamper people's life opportunities and also because those without financial or social resources are most likely to face afflictions that cause disability. For all these reasons, the aim and scope of the Universal Accessibility philosophy should be extended to include not only people with disabilities but also those affected by other barriers, and guidelines should address issues such as how to make content accessible to those with limited literacy or outdated technology.

A key goal of universal design is to develop flexible approaches that can be customized and adjusted for individual needs. In theory, such approaches should enable better designs of digital media and of technology-based development projects that can help meet the needs of people facing a range of challenges to access. These goals will be best achieved if the broad array of physical, digital, human, and social resources that contribute to the capacity to access and use technology effectively is taken under consideration, while also aiming to design solutions suitable to diverse local contexts.

Figure 1: Resources that Contribute to Effective use of New Technologies



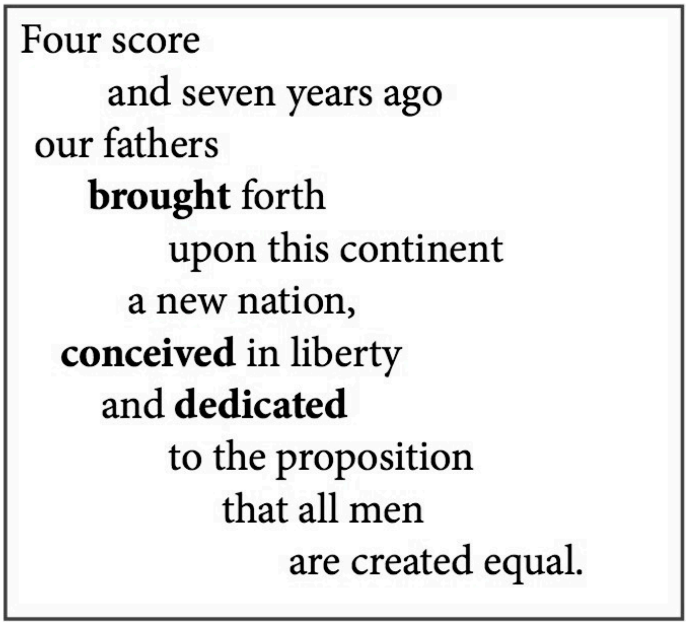
Reprinted with permission from Warschauer (2002)

Figure 2: Typology of Resources for Supported Text

Resource	**Description**
Presentational	Enables graphics and text to be presented in customizable ways
Navigational	Provides tools that allow reader to move between or within documents
Translational	Provides a simplified version of a document, paragraph, phrase or word in the same or different modality
Explanatory	Provides information that seeks to clarify the why, how, where, and what of some event, process, object, or content
Illustrative	Provides an example or visual representation of content in a text
Summarizing	Provides a condensation of the material
Enrichment	Provides supplementary information that adds to the readers' understanding or appreciation of the significance or historical context
Instructional	Provides questions, strategies, prompts or instruction to teach some aspect of a text or how to read and interpret a text
Notational	Provides tools for taking notes on a text or highlighting or marking it.
Collaborative	Provides tools for sharing with the author, other readers, or some other audience
Evaluational	Provides prompts, materials and assignments to assess student learning from a text

Adapted from Anderson-Inman & Horney (2007)

Figure 3: Visual-Syntactic Text Formatting



References

Anderson-Inman, L., & Horney, M. A. (2007). Supported eText: Assistive technology through text transformations. *Reading Research Quarterly*, *42*(1), 153-160.

Arora, P. (2010). Hope-in-the-Wall? A digital promise for free learning. *British Journal of Educational Technology*, *41*(5), 689-702.

Beuermann, D. W., Cristia, J., Cruz-Aguayo, Y., Cueto, S., & Ofer, M. (2013). Home computers and child outcomes: Short-term impacts from a randomized experiment in Peru. *NBER Working Paper*, *18818*. Retrieved from http://www.nber.org/papers/w18818

Castells, M. (1998). *End of Millennium.* Malden, MA: Blackwell.

Cervantes, R., Warschauer, M., Nardi, B., & Sambasivan, N. (2011). *Infrastructures for low-cost laptop use in Mexican schools*. Proceedings from 29th International Conference on Human Factors in Computing Systems. CHI 2011. ACM.

Cummins, J. (1991). Interdependence of first and second language proficiency in bilingual children. In E. Bialystok (Ed.), *Language processing in bilingual children* (pp. 70-89). Cambridge: Cambridge University Press.

de Melo, G., Machado, A., Alfonso, M., & Viera, M. (2013). Impacto del Plan Ceibal en el apredizaje. Evidencia de la major experiencia OLPC [Impact of Plan Ceibal on learning. Evidence from the largest OLPC program.] Instituto de Economía Documento de Trabajo 13/13 [Institute of the Economy Working Paper #13/13. Universidad de la Republica, Montevideo, Urguay. Retrieved October 1, 2014 from http://www.iecon.ccee.edu.uy/documentos-de-trabajo/.

Donner, J. (2008). Shrinking fourth world? Mobiles, development, and inclusion. In J. Katz (Ed.), *The handbook of mobile communication studies* (pp. 28-42). Cambridge, MA: MIT Press.

Duflo, E., & Hanna, R. (2005). Monitoring works. Getting teachers to come to schools. *NBER Working Paper No. 11880.* Retrived from http://www.nber.org/papers/w11880.

Fowler, G. A., & Bariyo, N. (2012). An e-reader revolution for Africa? *Wall Street Journal*.

Gurstein, M. (2000). *Community informatics: Enabling communities with information and communications technologies.* Hershey, PA: Idea Group.

Hasselbring, T. (2014). Udio: A technology-rich literacy experience for students with reading disabilities. Retrieved from http://www.edutopia.org/blog/udio-tech-platform-reading-disabilities-ted-hasselbring

James, J. (2011). Low-cost computers for education in developing countries. *Social Indicators Research*, *103*, 399-408. doi: 10.1007/s11205-010-9708-2w

Kling, R. (1999). What is social informatics and why does it matter? *D-Lib Magazine December 15, 2001*, *5*(1). Retrieved from http://www.dlib.org/dlib/january99/kling/01kling.html

Kling, R., & Lamb, R. (2001). IT and organizational change in digital economies: A sociotechnical approach. In E. Brynjolfsson & B. Kahin (Eds.), *Understanding the digital economy: Data, tools, and research* (pp. 295-324). Cambridge: MIT Press.

Kling, R. (2000). Learning about information technologies and social change: The contribution of social informatics. *The Information Society*, *16*(3), 1-36. doi:10.1080/019722400128284

Kraemer, K. L., Dedrick, J., & Sharma, P. (2009). One laptop per child: Vision vs. reality. *Communications of the ACM*, *52*(6), 66-73. doi:10.1145/1516046.1516063

(Eds.). (2001). *Community informatics: Shaping computer-mediated social networks.* London: Routledge.

Malamud, O., & Pop-Eleches, C. (2010). Home computer use and the development of human capital. NBER Working Paper No. 15814. Retrieved August 3, 2011 from http://www.nber.org/papers/w15814

Keeble, L., & Loader, B. (Eds.). (2001). *Community informatics: Shaping computer-mediated social networks.* London: Routledge.

Miniwatts Group (2014). World Internet users and population stats. Retrieved from http://www.internetworldstats.com/stats.htm

Mitra, S. (1999). Minimally evasive education for mass computer literacy. *CSI Communications*, *June*, 12-16.

Mitra, S. (2005). Self organizing systems for mass computer literacy: Findings from the 'hole in the wall' experiments. *International Journal of Development Issues*, *4*(1), 71-81. doi:10.1108/eb045849

Mitra, S., & Rana, V. (2001). Children and the Interenet: Experiments with minimally invasive education in India. *British Journal of Educational Technology*, *32*(2), 221-232. doi:10.1111/1467-8535.00192

Olson, P. (2013). This simple app could put e-books on millions of phones in the third world. Retrieved from http://www.forbes.com/sites/parmyolson/2013/04/09/a-simple-app-fights-illiteracy-putting-free-e-books-on-half-a-million-phones/

Pal, J., Patra, R., Nedevschi, S., Plauche, M., & Pawar, U. S. (2009). The case of the occasionally cheap computer. *Information Technologies and International Development*, *5*(1), 49-64.

Proctor, C. P., Dalton, B., Ucceli, P., Biancarosa, G., Mo, E., Snow, C. E., & Neugebauer, S. (2011). Improving comprehension online (ICON): Effects of deep vocabulary instruction with bilingual and monolingual fifth graders. *Reading and Writing: An Interdisciplinary Journal*, *24*(5), 517-544.

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning.* Alexandria, VA: Association of Supervision & Curriculum Development.

Russell, M., & Abrams, L. (2004). Instructional effects of computers for writing: The effect of state testing programs. *Teachers College Record*, *106*(6), 1332-1357. doi:10.1111/j.1467-9620.2004.00381.x

Vigdor, J. L., Ladd, H. F., & Martinez, E. (2014). Scaling the digital divide: Home computer and student technology. *Economic Inquiry*, *52*(3), 1103-1119.

Walker, R. C., Gordon, A. S., Schloss, P., Fletcher, C. R., Vogel, C., & Walker, S. (2007). Visual-syntactic text formatting: Theoretical basis and empirical evidence for impact on human reading. Paper presented at the IEEE Professional Communication Conference, 2007, Seattle, 1-14. Retrieved from http://ieeexplore.ieee.org

Walker, S., Schloss, P., Fletcher, C. R., Vogel, C. A., & Walker, R. C. (2005). Visual-syntactic text formatting: A new method to enhance online reading. *Reading Online*, *8*(6). Retrieved from http://www.readingonline.org/

Warschauer, M. (2002). Reconceptualizing the digital divide. *First Monday July 10, 2002*, *7*(7). Retrieved from http://www.firstmonday.dk/issues/issue7_7/warschauer

Warschauer, M. (2003a). Social capital and access. *Universal Access in the Information Society*, *2*(4), 315-330.

Warschauer, M. (2003b). Demystifying the digital divide. *Scientific American*, *289*(2), 42-27. doi:10.1038/scientificamerican0803-42

Warschauer, M. (2003c). *Technology and social inclusion: Rethinking the digital divide.* Cambridge: MIT Press.

Warschauer, M. (2006). *Laptops and literacy: Learning in the wireless classroom.* New York: Teachers College Press.

Warschauer, M. (2007). Information literacy in the laptop classroom. *Teachers College Record*, *109*(11), 2511-2540.

Warschauer, M. (2008). Laptops and literacy: A multi-site case study. *Pedagogies*, *3*(1), 52-67.

Warschauer, M. (2011). *Learning in the cloud: How (and why) to transform schools with digital media.* New York: Teachers College Press.

Warschauer, M. (2012). The digital divide and social inclusion. *America's Quarterly*, *6*(2), 130-135.

Warschauer, M., & Ames, M. (2010). Can One Laptop per Child save the world's poor? *Journal of International Affairs*, *64*(1), 33-51.

Warschauer, M., Cotten, S. R., & Ames, M. (2012). One Laptop per Child Birmingham: Case study of a radical reform. *International Journal of Learning and Media*, *3*(2).

Warschauer, M., & Matuchniak, T. (2010). New technology and digital worlds: Analyzing evidence of equity in access, use, and outcomes. *Review of Research in Education*, *34*(1), 179-225.

Warschauer, M., Park, Y., & Walker, R. (2011). Transforming digital reading with visual-syntactic text formatting. *JALT CALL Journal*, *7*(3), 255-270.

Warschauer, M., Zheng, B., Niiya, M., Cotten, S., & Farkas, G. (2014). Balancing the one-to-one equation: Equity and access in three laptop programs. *Equity & Excellence in Education, 47*(1), 46-62.

Zheng, B., Warschauer, M., & Farkas, G. (2013). Digital writing and diversity: The effects of school laptop programs on literacy processes and outcomes. *Journal of Educational Computing Research*, *48*(3), 267-299.