Designing for Accessibility: The Intersection of Instructional Design and Disability

Michele D. Estes, Cheryl L. Beverly, and Marco Castillo

Introduction

In this chapter, the authors address the concept of access, especially in terms of persons with disabilities. The authors focus on persons with disabilities, rather than special needs, for two reasons. First, access for persons with disabilities is specifically mandated by the Americans with Disabilities Act (ADA), Section 504 of the Rehabilitation Act, and the Individuals with Disabilities Education Improvement Act (IDEA). Second, although the Elementary and Secondary Education Act (United States Department of Education, n.d.-b) addresses students in poverty, minorities, those receiving special education services, and those with limited English language skills, issues of access that are relevant to persons with disabilities are often similar to the needs of individuals identified in ESEA. Indeed, provisions for access for persons with disabilities may benefit all learners including the nondisabled population.

The multiple and varied understandings of the concept and process of access, by education professionals, complicate any discussion of designing for access for individuals with and without disabilities. In the peer-reviewed literature, educational technology articles on the topic of access and disability tend to be limited, clustered in a few journals, with attention mostly given to physical access to content and resources, meeting legal access requirements, and introducing custom tools and apps in inclusive classrooms. In the persons with disabilities literature, these types of articles, on the topic of technology and access, tend to appear in very small

M. D. Estes (✉) · C. L. Beverly
Learning, Technology, and Leadership Education, College of Education, James Madison University, Harrisonburg, VA, USA
e-mail: estesmd@jmu.edu

M. Castillo
Universidad Catolica Silva Henriquez, Santiago, Región Metropolitana, Chile

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numbers in a wide range of journals, with access described in terms of physical, communication, cognitive, social/behavioral, and daily living access. In both bodies of literature, there are research articles about the role of technology in supporting learning for learners with disabilities. However, lack of physical access to technologies and resources and the impact this has on communications, social/behavioral issues, and independent daily living continue to be a theme.

Understanding similarities and differences in instructional design and disability is important. Professionals in these disciplines share a similar aim to ensure access to meaningful learning experiences that occur in a variety of environments, formats, and contexts. To that end, experts in these areas use terminologies and processes that may inform and enhance current practices. The problem driving this review of research was how instructional designers address access to meaningful learning experiences for persons with disabilities. The guiding question for this review was as follows: *What does the recent research literature tell us about how instructional designs and technology are made accessible for learners with disabilities?* To answer this question, the authors reviewed social sciences peer-reviewed research journal articles published from 2012 to 2018, with keywords relating to access, instructional design, and persons with disabilities. Findings addressed ways instructional design may be used to facilitate access to, and through, technology; as well as approaches to conducting relevant research and to sustaining solutions in practice. Central concepts emerging from a summary of this research include those defined in Table 1.

In addition to federal laws, policies such as the 2017 National Education Technology Plan Update, a core US policy document, articulate a vision for "... equity, active use, and collaborative leadership to make everywhere, all-the-time learning possible" (U. S. Department of Education, n.d.-f, para. 2). Collaborative research among experts in instructional design and technology, and disability, is needed to better understand how instructional design and technologies may be made more accessible. Such efforts may help expand the use of instructional design processes, and technologies, as tools that provide access to meaningful learning experiences and functioning of persons with disabilities.

Review Process

Both *disability* and *handicapped* were used as these terms are often used interchangeably and the authors did not want to exclude relevant research. The term *handicapped* has limited use in disciplines that focus on persons with disabilities such as occupational therapy, physical therapy, special education, rehabilitation, communication and speech, social work, counseling, nursing, and disability studies. However, the term is present in early US education and civil rights legislation, in disciplines with less engagement and/or knowledge of persons with disabilities, and in some international systems as evidenced in a SCOPUS search that yielded 14 articles, 5 of which were relevant to the topic of this paper. To ensure a broad look

Table 1 Central concepts emerging from the recent research literature

Concept	Definition
Access	"1 The means or opportunity to approach or enter a place" or "1.1 The right or opportunity to use or benefit from something" (English Oxford Living Dictionaries, 2018)
Accommodation and intervention for adult learners	Adaptation or adjustment to the learning and functioning contexts of adults with disabilities
Collaboration	"1 The action of working with someone to produce something" (English Oxford Living Dictionaries, 2018)
Disability	"The definition of disability varies depending on the purpose of its use. For purposes of nondiscrimination laws (e.g., the Americans with Disabilities Act, Section 503 of the Rehabilitation Act of 1973, and Section 188 of the Workforce Investment Act), a person with a disability is generally defined as someone who (1) has a physical or mental impairment that substantially limits one or more 'major life activities,' (2) has a record of such an impairment, or (3) is regarded as having such an impairment" (U. S. Department of Labor, n.d.-b) "Major life activities include, but are not limited to, caring for oneself, performing manual tasks, seeing, hearing, eating, sleeping, walking, standing, lifting, bending, speaking, breathing, learning, reading, concentrating, thinking, communicating, and working" (U. S. Congress, 2009, Sec. 12161. Definitions section) For purposes of special education, "Child with a disability means a child evaluated in accordance with §§300.304 through 300.311 as having an intellectual disability, a hearing impairment (including deafness), a speech or language impairment, a visual impairment (including blindness), a serious emotional disturbance (referred to in this part as 'emotional disturbance'), an orthopedic impairment, autism, traumatic brain injury, an other health impairment, a specific learning disability, deaf-blindness, or multiple disabilities, and who, by reason thereof, needs special education and related services" (U. S. Department of Education, n.d.-e)
Inclusive classrooms	"The fundamental principle of the inclusive school, as proposed in the Salamanca Statement, is that all students should learn together, where possible, and that ordinary schools must recognise and respond to the diverse needs of their students while also having a continuum of support and services to match those needs" (as cited in the Department of Education and Science, 2007, p. 15)
Instructional design process	"...The systematic development of instructional specifications using learning and instructional theory to ensure the quality of instruction. It is the entire process of analysis of learning needs and goals and the development of a delivery system to meet those needs. It includes development of instructional materials and activities; and tryout and evaluation of all instruction and learner activities" (University of Michigan, 2003, para. 1)
Professional development	"The development of competence or expertise in one's profession; the process of acquiring the skills needed to improve performance in a job" (English Oxford Living Dictionaries, 2018)

(continued)

Table 1 (continued)

Concept	Definition
Special education	IDEA defines special education as: 1. "...Specially designed instruction, at no cost to the parents, to meet the unique needs of a child with a disability, including— (i) Instruction conducted in the classroom, in the home, in hospitals and institutions, and in other settings; and (ii) instruction in physical education" (U. S. Department of Education, n.d.-a, Sec. 300.39 (a) (1) (i)) 2. Special education includes each of the following, if the services otherwise meet the requirements of paragraph (a)(1) of this section— (i) Speech-language pathology services, or any other related service, if the service is considered special education rather than a related service under State standards; (ii) Travel training; and (iii) Vocational education" (U. S. Department of Education, n.d.-a, Individuals with Disabilities Education Act, Part B, Subpart A, Section 300.39 Special Education)
Universal Design for Learning (UDL)	"A scientifically valid framework for guiding educational practice that — (A) provides flexibility in the ways information is presented, in the ways students respond or demonstrate knowledge and skills, and in the ways students are engaged; and (B) reduces barriers in instruction, provides appropriate accommodations, supports, and challenges, and maintains high achievement expectations for all students, including students with disabilities and students who are limited English proficient" (U. S. Department of Education, n.d.-b, para. 3)

at relevant research, the authors included both *disability* and *handicapped* as search terms.

The search term *special education* was not used as the authors did not want to limit the parameters of this chapter to special education. Special education addresses a more limited audience of learners with disabilities than occurs in the general population and under specific procedural identification and service requirements that are not reflected in broader practices of educating/providing access to persons with disabilities. *Universal Design for Learning* (UDL) was used, as this framework is specifically mentioned in the 2015 reauthorization of ESEA and the US Office of Educational Technology's *National Education Technology Plan*; however, the authors did not focus this review solely to UDL as a tool for access to learning. *Instructional design*, *technology*, and *access* were used as research terms as they are subjects of interest for this review. The quality of the articles reviewed was established by limiting the search criteria to research only, peer reviewed, journals, conference proceedings, and current (2012–2018). The authors did limit the studies to English language but did not limit them to the United States.

The authors searched SCOPUS open access articles in the social sciences, for this review of research literature published between 2012 and 2018. Descriptors used were *disability* and *access* and *technology* (30 articles found in SCOPUS although only a few were relevant), *disability* and *access* and *instructional design* (two relevant practice articles found in SCOPUS), *disability* and *access* and *UDL* (six relevant SCOPUS documents/four unique), *handicapped* and *access* and *technology* (14 found in SCOPUS/five relevant), *handicapped* and *access* and *instructional design* (zero found in SCOPUS), and *handicapped* and *access* and *UDL* (zero found in SCOPUS).

Fifty-three journal articles were identified in disability-related literature using Education Resources Information Center (ERIC) and Education Research Complete search engines using the same descriptor chains as with SCOPUS. Thirty-two of the articles met the search criteria of research, peer reviewed and published between 2012 and 2018. *Disability and Rehabilitation: Assistive Technology* had the most articles (six), and the *Journal of Special Education Technology* had the second most articles (five). Three international journals, *Canadian Journal of Higher Education* (2), *Africa Education Review* (1), and *British Journal of Educational Technology* (1), were also identified as having research regarding the topic.

Starcic and Bagon (2014) conducted an extensive review of the information and communications technology (ICT) and disability literature in seven different educational technology journals, between 1970 and 2011. ICT, information and communications technology, is described by UNESCO as "including mainstream technologies, assistive technologies, media and accessible formats, educational software, and virtual learning environments" (as cited in Ramos & de Andrade, 2016, p. 626). One interesting finding they reported was that of these journals, the *British Journal of Educational Technology* (BJET) had published the most articles in this area. In this review, a keyword search for the term *accessibility* in the *British Journal of Educational Technology* (BJET) yielded seven results within the last 5 years. A keyword search for *access* in this same journal led to articles referring to access to computers and digital technologies and access to information such as that afforded by use of the Internet and massive open online courses (MOOCs), as opposed to access in relation to disability. A search of the *BJET* for keyword *disability* led to three relevant research articles between 2012 and 2018. Two of these reported results from studies involving information and communications technologies (ICTs) and children with disabilities.

Summary of Research Literature

Persons with Disability Literature

A review of sample research regarding education of persons with disabilities showed a variety of research designs, from review of the research/professional literature to surveys, focus groups, case studies, interviews, mixed methods, multiple baselines across participants to single subject. This research tended to address access and use of technology and barriers to its use.

Nonexperimental research involved large groups of persons with disabilities and/or their service providers and carers. Experimental research tended to focus on a specific technology or Universal Design for Learning (UDL), specific disability population, specific skill set, and specific age group (elementary, high school, adults) in a clinical setting, with one-on-one treatments and small sample sizes. For example, the iPad with adaptive technology and/or stand-alone technology was used with learners who are on the autism spectrum, as a tool to build requesting of an object or activity (Couper et al., 2014; Sigafoos et al., 2013), lowering levels of challenging behavior and increasing levels of academic engagement (Neely, Rispoli, Camargo, Davis, & Boles, 2013), performing communication sequences (Waddington et al., 2014), learning engagement (Arthanat, Curtin, & Knotak, 2013), engaging in intentional communication (McEwen, 2014), and identifying, maintaining, and generalizing a picture vocabulary. Dallas, McCarthy, and Long (2016) cautioned that “Assessing educational technology for effectiveness is important prior to making recommendations for widespread use” (p. 3).

Educational Technology Literature

A cursory look at educational technology articles published in leading journals, issued 2012–2018, shows that researchers have published in the area of accessibility and/or disability to a limited degree. Research designs vary; participant disabilities range in complexity across studies, as do the tools and learning environments of interest.

Experimental research existed but was uncommon in the educational technology literature, in the area of disabilities. One such study was conducted in China. Researchers Zhang and Zhou (2016) recruited 142 children with math learning difficulties (MLD) to participate. Students in the experimental group used an online learning system at home over time and showed significant gains in achievement. In another example, this time in Mexico, Felix, Mena, Ostos, and Maestre (2017) conducted a pilot study of computer-based learning tool HATLE which was designed to support reading and writing therapies with children determined to have moderate intellectual disabilities. The software design was informed by multimedia principles and learning theories with careful attention paid to instructional design that supports individual learning needs. Significant improvements were found in the experimental group in areas of single-word reading and in handwriting form, with improvement in letter identification, handwriting legibility, and spelling. The researchers described some of the affordances of HATLE as having “a more personal and responsive interface, offering instant gratification to students with limited patience” (p. 621).

Published, nonexperimental research in the current review typically involved qualitative methods such as case study, observation, and interview and/or survey, mixed methods, and/or explanatory sequential mixed methods. In Slovenia, for example, Starcic, Cotic, and Zajc (2013) tested the use of a tangible user interface in an inclusive math classroom. Through the interface, geometric concepts were taught to students who were considered typical students, students with learning difficulties, and students with fine motor challenges. While all learners showed some improvements, participants with fine motor skill issues appeared to benefit most from the tangible user interface, over paper and pencil. They were able to draw accurately and without assistance and could collaborate with others using the computer, with confidence. This study involved an iterative, design-based research methodology where the tangible user interface was adapted for students with special needs.

Summary of Research Findings

Perhaps the major result of this review of the literature is the understanding that issues of accessibility for persons with disabilities are complicated and complex. For example, the term *access* appears to be more narrowly defined in educational technology literature than in the disability literature. Educational technology literature addressing *access* tends to offer implications for policies and practices that support physical access and/or help overcome a digital divide (Bharuthram & Kies, 2013; Hartnett, 2017; Taylor, Taylor, & Vlaev, 2017; Vrasidas, 2015) and/or report issues with technology reliability (Hartnett, 2017; Rehn, Maor, & McConney, 2017; Scott, Nerminathan, Alexander, & Phelps, 2015) but not necessarily in relation to disability, special needs, or even learning. Educational technology research could define access more broadly in relation to technology and instructional design, to also include levels of social access (Cano & Sanchez-Iborra, 2015; Foley & Ferri, 2012; Hayhoe, Roger, Eldritch-Böersen, & Kelland, 2015; Rieber & Estes, 2017) and cognitive access (Monteiro Cruz & Monteiro, 2013; Rieber & Estes, 2017) for learners with and without disabilities.

Universal Design for Learning (UDL)

Research addressing access often focuses on Universal Design for Learning principles and models. However, as Rao, Ok, and Bryant (2014) discovered through a review of research on universal design models in education, researchers use a range of research designs and report their application of UD principles in various ways with no standard formats for UD use. The researchers also reported that UD principles are used for a variety of purposes, to examine a variety of learning factors and to influence accommodation decisions and technology-based environment design, and are used in professional development and classroom practice. The degree of variation in research of UD principles proves challenging for analysis, interpretation, and effective use of UD in educational practice (Rao et al., 2014). Further, it is important to recognize that generic UDL practices may not be the least restrictive for every learner with a disability. An analysis of the learner's abilities and disabilities, context, experience, and motivation will be key to the success of any learning or functioning with technology. Analysis of the instructor's knowledge of UDL, understanding of UDL in context, and skills in applying UDL principles is also necessary. Effective implementation of UDL (see CAST.org) requires collaboration between the learner, the instructor, and an instructional designer.

An example where collaboration with an instructional designer could have improved UDL outcomes is the exploratory study of UDL conducted by King-Sears et al. (2015) in an inclusive high school chemistry classroom populated by learners without disabilities and learners with high-incidence disabilities (HID). Learners with HID in both UDL and comparison groups retained less knowledge at delayed post-assessment. Learners with HID who were taught with UDL performed higher than did the comparison group of persons with HID, but the learners without disabilities in the UDL group performed more poorly than did those without UDL instruction. In her work with adult basic education (ABE) learners with specific learning disabilities (one of thirteen disabilities defined in IDEA), Gregg (2012) noted that "Access to learning for the ABE learner with LD will also depend on universally designed technology instruction and testing environments so that the accommodations will be built into systems and available for all individuals" (p. 59). UDL principles and models typically are used to create inclusive classrooms, supporting the learning of all students. Not all research on supporting learners' access to and in inclusive classrooms focuses on UDL. Research using educational technology as an aide to access and inclusion is being conducted.

Inclusive Classrooms

Zhang, Trussell, Gallegos, and Asam (2015) conducted an exploratory study of the use of three math apps on mobile devices in an inclusive, fourth-grade classroom. Eighteen participants were students considered at risk, diagnosed with one or more disabilities—autism, emotional disorder, dyslexia, and/or learning disability—or considered nondisabled and not at risk. The math topics of interest were decimals and multiplication. Participants used related apps during four 80–90 minute sessions, over the period of a month. In each session, the teacher first taught students how to use the apps. Mobile devices were selected to reduce barriers to learning gains such as difficulty a student may experience when otherwise using a mouse, having to keep pace with others during group instruction, and/or struggling without immediate feedback afforded by the technology. Results showed gains for all students but particularly for those who were considered at risk or disabled which helped shrink the achievement gap between that group and the students who were considered typical for the purposes of this study.

In Spain, Cano and Sanchez-Iborra (2015) involved teachers in the design and research of a software application called PLAIME, to help teach students music skills. Rather than group students by disability, researchers conducted a pretest and used the results to divide students into two groups according to intellectual capacity. Groups were created to ensure participants could make sufficient progress and keep pace. The teachers delivered ten sessions for one hour a week and made adjustments after the first session to adapt the "content to each group's learning progress in subsequent sessions" (p. 265). Researchers used mixed methods including but not limited to case study observation. "...Students showed a high improvement in their music knowledge, an enhancement in their perceptual, cognitive, and social skills, and were able to perfectly manage the computer program by themselves" (p. 273). Findings also suggested that "...teachers must first actively adopt and learn the technology for this to be successful...teachers should be an active part in the development of ICT education tools" (p. 274). As illustrated by these two studies, designing training for the teacher and student on how to use the technology is a key to successful inclusion. Although there is a growing body of research focusing on K–12 and higher education inclusion, there is a lack of research focusing on inclusion across functional life domains for adults with disabilities.

Adult Learners: Accommodation and Intervention

Several researchers (Chadwick, Wesson, & Fullwood, 2013; Hoppestad, 2013) reported that although various technology devices and interventions have been developed for persons with all types of disabilities, there is a lack of research into methods to help persons, especially adults, with severe developmental and intellectual disabilities. These persons have been shown to underutilize computers and the Internet. Accommodations should be made for not only children but also adult learners (Terblanché, 2012). Bouck and Flanagan (2016); Flanagan, Bouck, and Richardson (2013); Hoppestad, Stephenson, and Limbrick (2015); and Tanis et al. (2012) reported an overall underutilization of devices across functional life domains for adults with severe disabilities and a need for research on using the technology in informal contexts. The review identified barriers to access as costs, assessment, usability, breakage and repair of the device, replacement of the device, assistance using the device, amount of time needed to procure the right device, insufficient evidence of safety and outcomes, adapting technology to other treatments and information, and lack of experience of providers (Flanagan et al., 2013; Hook, Verbaan, Durrant, Olivier, & Wright, 2014; Tanis et al., 2012).

Rivera, Hudson, Weiss, and Zambone (2017) connect access and inclusion in the classroom to access and inclusion in nonclassroom contexts. Rivera et al. believe that:

> ...it is necessary for classroom staff to take the lead when conceptualizing and implementing an intervention to better ensure continued use of the intervention (Coburn, 2003) and to determine what kind of supports and training might be needed in the future... (p. 347).

Research questions and methodologies should strive to include adults with severe disabilities; daily living, financial, work, social, recreational, communicative, and authentic use of the technology with the individual with disabilities; research with persons with multiple disabilities; the use of technology for persons with disabilities by general education; and related service providers, carers, parents, and individuals with disabilities (Bouck & Flanagan, 2016; Hoppestad, 2013; Kagohara et al., 2012;

Okolo & Diedrich, 2014; Penton & Gustafson, 2014). Research focusing on how persons with disabilities or their carers/parents access information, the usability of the information, the accuracy and recency of the information, and the provider's attitude toward persons with disabilities (Chadwick et al., 2013; Tanis et al., 2012) is also needed.

The reviewed research identified the importance of training and collaboration with the educator and/or carer to support access and inclusion in all learning spaces including the classroom environment. The research on adults with disabilities also identified the role of training and professional development for carers and family members.

Training and Professional Development

Given that the teacher will have an impact on student use of digital technologies (Heiman, Fichten, Olenik-Shemesh, Keshet, & Jorgensen, 2017), there is a need for professional development and training of the team of professionals, family, carers, and persons with disabilities to (1) grow knowledge of technologies available; (2) grow understanding of the impact of disability on the learning and functioning of the person; (3) analyze a person with disabilities' talents and limitations and the technology options; (4) develop confidence in the user and supporter of the technology; (5) develop aids for use by carers and persons with disabilities regarding the safety, maintenance, repair, and updating of the technology; (6) modify technology to meet the unique needs and use by the person with a disability; and (7) use the technology across environments, functions, and time.

Hall, Cohen, Vue, and Ganley (2015) and Morningstar, Shogren, Lee, and Born (2015) believe that the role of a teacher, with expertise and intuition in the use of technology with students with disabilities, greatly impacts the effectiveness of technology use, as well as the access and participation of all learners in the classroom. Okolo and Diedrich (2014) found that teachers use technology to instruct learners with disabilities less frequently than they use technologies in their own lives. These teachers indicated a need for professional development, and better access to technology, to support their use of assistive technologies (AT) with their learners.

Researchers (Lenker, Harris, Taugher, & Smith, 2013; Penton & Gustafson, 2014) noted that consumers with disabilities recognized that the use of assistive technologies promoted their independence, subjective well-being, and more equitable access to many aspects of life. However, these same consumers were dissatisfied with the limited knowledge and training of service providers, lack of funding available in existing programs and services, and the length of time to acquire the device.

ICT access, research, and related educator training are important (European Agency for Development in Special Needs Education, 2013). There is a need to further investigate the digital divide between persons with disabilities and those without (Chadwick et al., 2013) and the goodness of fit between the individual and the technology (Leopold, Lourie, Petrasb, & Eliasa, 2015). Access is important for the integration and equity of individuals with disabilities (Roig-Vila, Ferrández, & Ferri-Miralles, 2014).

Persons with disabilities should be taught how to use digital technologies at an early age, along with students who are not labeled as having disabilities (Drigas, Pappas, & Lytras, 2016). Lidström, Granlund, and Hemmingsson (2012) found, for instance, that "...students with a physical disability have restricted participation in some computer-based educational activities in comparison to students from the general population" (p. 21). When compared to students without disabilities, students with disabilities often lack access to ICTs that could be useful (Fisher & Shogren, 2016). Access, interventions conducted online, and the support of family may also support significant improvements for students with learning difficulties (Zhang & Zhou, 2016). Students with disabilities who receive materials in a variety of forms may "be able to connect with these materials after and outside of class to do homework, prepare for tests, complete research projects, and discuss what they are learning with other students, teachers, and their parents" (Vesel & Robillard, 2013, p. 364). Early intervention is not always possible, and accommodations should also be made for adult learners (Terblanché, 2012). In order to best serve the population of persons with disabilities, research questions and methods addressing instructional design, access, and disability should address the life span and life functions of persons with disabilities. The inclusion of instructional designers in all stages of intervention, from research to teaching and assessment to life skills, benefits all stakeholders involved with persons with disabilities.

It is important that learners and educators understand the technology and content before engaging in research studies of effectiveness. However, Kumar and Owston (2016) note a lack of knowledge, training, and professional development for teachers in this area. To strengthen the rigor of design and research and maximize effectiveness, educational technologists and educators/carers of persons with disabilities should collaborate during the research process (de Anna et al., 2014) and/or during the instructional design process.

Collaboration

When conducting research that informs instructional design for learners with disabilities, techniques such as situated learning (de Anna et al., 2014), scaffolding (Zhang et al., 2015), and iteration (Starcic et al., 2013) should be used. Collaborative and situated research designs are likely to improve learning and support transfer of learning to authentic contexts. Researchers should pre-group participants by cognitive or intellectual level rather than by disability; allow for iteration and adjustments that best support learners with disabilities as the study continues; involve the educator, related service providers, family members, and carers in the design and training of the technology to be used with learners (Cano & Sanchez-Iborra, 2015); and involve the learners in technology training before expecting its use.

Ratliffe, Rao, Skouge, and Peter (2012) discovered the importance of collaborating with cultural guides while conducting a study in the Pacific Islands region where the issue of technology access and use for individuals with disabilities is "...complicated by the lack of resources, cultural values that differ from those presenting the mandates, and complexities of hierarchy, relationships, and position in the islands" (p. 209). For example, cultural mores "...value protection and safeguarding for persons with disabilities over helping them become independent" (p. 213). Findings of this multiple case study revealed the importance of collaboration at all levels, barriers to procurement, and the iterative process of supporting learners with disabilities.

Using Instructional Design to Facilitate Access to, and through, Technology

As noted in previous sections of this summary, instructional designers, as a collaborative partner, have a role in facilitating access to and through technology. The instructional design process generally includes the phases of analysis, design, development, implementation, and evaluation. However, while "learner analysis is a cornerstone of instructional design theory and practice, the consideration of characteristics of people with disabilities is rarely done" (Rieber & Estes, 2017, p. 9). An analysis of the talents and challenges of learners with disabilities must include, at minimum, a nuanced review of prior experiences, skills, and motivation for successful learning or functioning with technology. This type of analysis requires collaboration among the learner with disabilities, the teacher, other carers, the family, and the instructional designer. Outcomes should offer insights into why the learner is unable to transfer classroom content and skills into their multiple, everyday contexts. Further, such collaboration allows the instructional designer to see how to maximize what the learner can do rather than focusing solely on the disability.

A critical analysis of context and tasks is necessary. Carver, Ganus, Ivey, Plummer, and Eubank (2016) call for researchers to focus on the factors influencing interactions between a person with a disability and his/her environment(s). Research focusing on access to learning environment(s) needs to address learners with and without disabilities (Starcic & Bagon, 2014). It is important to understand that although a classroom may be considered inclusive, one should question whether students with disabilities do have full access to the educational experience (Edyburn & Edyburn, 2012). Although inclusion is not mandated by US federal legislation, public education is mandated to ensure students with disabilities learn, to the extent appropriate, with their nondisabled peers. US public education is also mandated to "use technology, consistent with the principles of universal design for learning, to support the learning needs of all students, including children with disabilities and English learners" (US Congress, 2016, p. 220).

Universal design principles call for educators to design curriculum and leverage the features of digital tools to support a very wide range of individual learner needs. Digital technologies and related intervention strategies hold promise for learners who are, and are not, diagnosed as having one or more disabilities (Heiman et al., 2017; Kumar & Owston, 2016; Starcic et al., 2013). In order to meet these mandates, collaborative partners will need access to, and training for, the use of technologies.

Strategies and Challenges

Findings in the recent reviewed research literature can inform instructional design in a number of ways. When addressing learners on the autism spectrum and/or with developmental disabilities, Hill and Flores (2014) cautioned that educators should begin by teaching with low-tech strategies before introducing technology. For example, a student who does not understand cause and effect will not understand how to use switches to access a toy or to turn on or off a light, to select a word on a computer, or to otherwise interact with the environment. This mirrors Rodriguez, Strnadova, and Cumming (2013) recognition of the need for educators to plan the introduction and use of devices prior to introducing them.

Hollins and Foley (2013) noted that cognitive and behavioral strategies also impact learner performance online. The idea that instructional designs should address academic, social, behavioral, communication, and motivation challenges is inferred, if not explicit, in the current literature. Foley and Ferri (2012) write that designers should:

> ...consider the needs of those with cognitive, sensory and physical disabilities as important sources of diversity and complexity necessary to inform the design of technology to increase accessibility and usability for all users...[and] enhance the "cool" factor. Accessible technology would also be grounded in the understanding that technology cannot be isolated from the social context, and the knowledge that if technology is to reduce social isolation, it must be designed with social inclusion in mind (p. 199).

As one example, a 19-year-old male with a significant specific learning disability should have technology that looks and performs appropriately for his developmental level and age. His text-to-voice app would have a male adult voice and vocabulary, and his devices would not be covered with childish pictures or images.

Design and technology best practices in the area of disabilities tend to address a specific disability and often a specific learner within that category of disability. Many studies occur in a clinical setting for one-on-one evaluation and matchmaking of learner and technology. The complex nature of disability makes it challenging, if not impossible in some cases, to generalize research findings and design solutions that solve access problems for many different students. While research that occurs in an authentic setting may yield practical results, these studies often lack a large enough sample size, or empirical research design, to yield generalizable results. As Rivera et al. (2017) noted, the use of higher student-teacher ratios can allow for more efficient instructional situations and additional knowledge gain for students with developmental disabilities. A challenge for collaborative partners is to be aware of the complexities and implications of the person's disability, learning environments, activities, resources, and instructional pedagogies encountered.

Implications for instructional designers include the need to expand awareness and demonstrate matchmaking skills during the analysis phase of the ADDIE process. To do this, instructional designers might refer to frameworks used to help map course elements and universal design principles (Rao, Edelen-Smith, & Wailehua, 2015) or to help match needs and preferences to technology features (Loitsch, Weber, Kaklanis, Votis, & Tzovaras, 2017):

> The goal is to allow educators to quickly and easily develop digital instructional materials that are simultaneously accessible, flexible, and engaging for diverse learners such that supports are embedded into the curriculum for all students to use as needed (Edyburn & Edyburn, 2012, p. 199).

Learners with a specific learning disability may need less technology support over time as they master learning strategies or may need more sophisticated technology support as they become a more sophisticated and complex learner. Alternatively, a learner may have a regressive disability such as cystic fibrosis. As the disease progresses, it impacts developmental levels and, therefore, the technologies used successfully in the past become outdated and less effective. For these reasons, instructional designers must be flexible and iterative in their thinking about the nature of design and technology use, over time, and in authentic contexts.

Instructional designers should develop expertise in the legal requirements for accessibility and the tools used to test for web accessibility, when designing eLearning. When considering physical and legal forms of accessibility, such as following set guidelines, policies, and regulations, it is important to not only use automated tools but also include a qualitative check of accessibility (Kumar & Owston, 2016). It is also important to move beyond the letter of the law, to understand the intent of the law for learners with disabilities.

Meeting the intent of federal civil rights and education legislations may consist of instructional designers making designs accessible and usable at the onset of the design process and being flexible and iterative in the design process to account for significant differences. In addition, instructional designers should develop an appreciation for responsive teaching (Foley & Ferri, 2012; Griful-Freixenet, Struyven, Verstichele, & Andries, 2017), technologies (Loitsch et al., 2017), and tiered learning experiences (Edyburn & Edyburn, 2012). It is also important to consider the significant impact that effectively designed digital technologies may have on learners with a range of disabilities. In the United States, the Individuals with Disabilities Education Improvement Act (IDEA) identifies thirteen disabilities, while the Americans with Disabilities Act (ADA) applies to everyone who qualifies as disabled within a broader definition. IDEA serves persons who meet a set of eligibility criteria from birth to graduation of 12th grade, or age 21, while the ADA serves individuals across the life span.

By partnering with disability experts, persons with disabilities, their carers, and instructional designers may increase awareness of, and sensitivity to, the nature of varying abilities and the dynamics of power and culture associated with disability. For example, Haualand (2014) wrote this about video interpreting services:

> ...organisation of the technology and service within an existing sociotechnical system places the users in a more equal position relative to others...the greater the integration of systems of heterogeneous actors, the greater the flow of agency and the less disabled – or different – the actors become (p. 287).

Further, the designer should be aware of implementation issues such as those shifting responsibility more heavily to learners with disabilities than to other learners, requiring, for example, that the learner with disability manages additional resources, processes, and self-advocacy efforts, while also attempting to learn the material. This may require additional time and training—of the person with the disability, the carer(s), and the educator—to implement effectively.

Sustainability

Through Policy

There are a number of policies and standards around the world intended to inform, guide, and sustain movements toward more accessible education, technology, research, and practice. Web Content Accessibility Guidelines (WCAG 1.0 and WCAG 2.0), for example, are international standards for accessible web design (see https://www.w3.org/standards/). The *United Nations Convention on the Rights of Persons with Disabilities* (UNCRPD) has been ratified by member states in the Africas, the Americas, Asia, Europe, and Oceania (see https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html). Regional United Nations policies including but not limited to the *Biwako Millennium Framework (BMF)* (see https://www.unescap.org/search/node/biwako) of the United Nations Economic and Social Commission for Asia and the Pacific were mentioned in the disability and ICT literature (Ratliffe et al., 2012). The *European and International Policy Supporting ICT for Inclusion* (search for "ICT" at https://www.european-agency.org/) addresses equity in educational opportunities, technology access, professional development, research and development, and data collection and monitoring of progress in the European and international communities. The United States has various civil rights and education policies that address access, such as those shown in Table 2. Knowledge of the policies and their operational regulations, as well as the skills to implement them, assess outcomes, and advocate for resources and time, can ensure sustained efforts for access to and through technology for persons with disabilities.

Table 2 Key federal laws in the United States relating to persons with disabilities

Americans with Disabilities Act	The Americans with Disabilities Act (ADA) became law in 1990. "The Americans with Disabilities Act (ADA) prohibits discrimination against people with disabilities in several areas, including employment, transportation, public accommodations, communications and access to state and local government' programs and services" (U. S. Department of Labor, n.d.-b, Americans with Disabilities Act section, para. 1). The ADA was amended in 2008, regulations were revised in 2010, and revisions of ADA Title II and III regulations were made in 2016
Every Student Succeeds Act (ESSA)	ESEA was reauthorized in 2015, replacing the 2002 reauthorization (NCLB), as the ESSA. ESSA ensures success of all students by emphasizing critical protections for students who are disadvantaged or have high needs, as well as requiring that all students be prepared to succeed in college and careers (U. S. Department of Education, n.d.-c)
The Individuals with Disabilities Education Act (IDEA)	"The Individuals with Disabilities Education Act (IDEA) is a law that makes available a free appropriate public education to eligible children with disabilities throughout the nation and ensures special education and related services to those children...Congress reauthorized the IDEA in 2004 retitling it as the Individuals with Disabilities Education Improvement Act...Congress most recently amended the IDEA through Public Law 114–95, the Every Student Succeeds Act, in December 2015" (U. S. Department of Education, n.d.-a, About IDEA section)
Section 504 of the 1973 Rehabilitation Act	"Section 504 of the Rehabilitation Act of 1973 prohibits discrimination against an otherwise qualified individual with a disability solely by reason of disability in any program or activity receiving federal financial assistance or under any program or activity conducted by an executive agency or the US Postal Service. Section 504 was the first federal civil rights law generally prohibiting discrimination against individuals with disabilities. The concepts of Section 504 and its implementing regulations were used in crafting the Americans with Disabilities Act (ADA) in 1990. The ADA and Section 504 are, therefore, very similar and have some overlapping coverage but also have several important distinctions" (Brougher, 2010, p. 1)
Workforce Innovation and Opportunity Act (WIOA)	"The Workforce Innovation and Opportunity Act (WIOA) became law on July 22, 2014. WIOA is designed to help job seekers access employment, education, training, and support services to succeed in the labor market and to match employers with the skilled workers they need to compete in the global economy...Section 188 of the WIOA prohibits discrimination against all individuals in the United States on the basis of race, color, religion, sex, national origin, age, disability, political affiliation or belief, and against beneficiaries on the basis of either citizenship/status as a lawfully admitted immigrant authorized to work in the United States or participation in any WIOA title I-financially assisted program or activity" (U. S. Department of Labor, n.d.-a, Employment and Training Administration, Disability and Employment Online, para. 1 and 2)

Through ID Practice

In addition to broad policies and practices, educational technology researchers have proposed frameworks, models, and practical tools for planning, developing, implementing, monitoring, and evaluating access of, or with, technology for educating persons with disabilities. The article by Edyburn and Edyburn (2012) *Tools for Creating Accessible, Tiered, and Multilingual Web-Based Curricula* seems particularly relevant and practical. The authors propose connecting instructional design and learner characteristics to create "diversity blueprints" (p. 201). As another example, Rao, Edelen-Smith, and Wailehua (2015) offer a detailed framework for applying principles of various forms of universal design to effective pedagogical practice. They encourage instructional designers to expand thinking about learner characteristics during the analysis phase.

Analysis of learners, content, environments, activities, transferability, and transportability is key to sustainable access and success. Rapid prototyping is necessary to ensure the technology is accommodating learners rather than learners adjusting to the technology. The number and nature of nuances are significant. These are often not immediately recognized by readers outside the discipline, in publications that document needs of persons with disabilities and/or technology affordances that provide access. To design a successful experience, we must focus on learner abilities, at least as much as their disabilities. Learner analysis should be expanded to include each developmental domain, in a variety of authentic environments, activities, and developmental ages, thus facilitating sustainability of instructional design for access to/through technology.

Through Enhanced Awareness and Collaboration

A detriment to sustaining ID for access and, indeed, efforts for access to/through technology is the lack of reference to *instructional design* in the reviewed disability literature. This suggests that many educators and other carers either are unaware of instructional design as an area of study or lack understanding and use of it in their research and instruction/interventions. Hoppestad (2013) noted a lack of research regarding methods to help persons with disabilities, especially adults with severe disabilities, to access technology in a useful way. Access to the technology in a timely and efficient way, as well as access to comprehensible information on how to introduce and train the use of technology in a variety of authentic contexts and monitor effectiveness of use, is needed. Problem-solving to reduce the costs in terms of time, funds, frustrations, and wariness of technology should be a collaborative effort among instructional designers and disability specialists, at a minimum. In order to conduct collaborative disability and access research involving the design of instruction, partners should first agree to common definitions, such as those for access, UDL, inclusive classrooms, and differentiation within disabilities.

Through Research

Researchers and findings in the literature, both explicitly and implicitly, call for improved collaboration among professionals to ensure continued services and aids (Bouck & Flanagan, 2016), direct outreach and instruction to parents and carers of persons with disabilities (Okolo & Diedrich, 2014), and offer comprehensive, systemic, and inclusive support for technology and its use (Tanis et al., 2012). Relevant and sustainable research and outcomes depend upon the sharing of resources. Resources include but are not limited to knowledge, access to persons with disabilities, access to educators, related service providers, carers and parents, access to the curriculum and pedagogies in use, and access to the various learning environments and technologies for persons with disabilities.

When research is focused on small samples, or is limited to specific hardware and software with a single population of disability, or for a particular academic purpose, we must address issues of relevance and sustainability. To be sustainable, we need to integrate our knowledge, skills, and resources across disciplines to develop research that is replicable and generalizable in authentic contexts and/or that leads to further study of the access, equity, learning, and design questions that drive this research.

In educational technology literature, the focus is typically on strategies rather than hardware; however, in the persons with disabilities literature, the focus is often on the hardware or app as a tool to an outcome. Too often, in that literature, the description of strategy used with the technology is missing or precise in a one-to-one, isolated setting. Ideally, these bodies of literature would blend, and the experts would partner to design interventions to include hardware, apps, and strategies with the focus always on the desired outcome, in the desired context, with a specific learner with a disability. As noted earlier in this chapter, understanding issues of instructional design and accessibility for persons with disabilities requires recognition and comfort with the complicated and complex. For the authors of this chapter, along with understanding came critical reflection of our disciplines and more questions.

Reflective Questions

Perhaps the disciplines of instructional design and disability should be asking whether evidence-based practices that integrate the variety of knowledge and skills of each other's disciplines are being identified. Are we creating authentic, generalizable, transferable, and transportable research outcomes that benefit all learners, and are we doing that by collaborating with others who have expertise other than our own? Are we aware and sensitive to the different definitions of shared terminologies and how that may impact our understanding of research and practice? Are we narrowly defining our discipline's focus, thereby limiting the efficiency and effectiveness of our professional practices and outcomes?

Are we designing useful interventions that account for the value of the task, the expectation of success or failure, and the cost to the learner? If a designer generates material, activities, or environments in which a learner's initial efforts are not successful, learners with disabilities—particularly those who do not value the knowledge or skill—will not persist. The expectation of failure and the emotional cost are greater than the value of the knowledge or skill to the learner.

Are we sensitive to, and able to leverage, existing policies, research methods, practices, frameworks, and models to make our instructional designs more accessible? Are we using instructional design and technologies to remove barriers to access on multiple levels for persons with disabilities? Are we comfortable enough with disequilibrium to risk collaboration with others engaged in the research and practice of instructional design, educational technology, access, and persons with disabilities? And perhaps most importantly, what barriers have been created to impede such collaboration and why have they not been minimized?

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