Accessible Cyberlearning: A Community Report of the Current State and Recommendations for the Future

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Abstract

Given rapid increases in the quantity and variety of formal and informal learning practices and research that make use of digital technologies, it is important to ensure that all potential students can benefit from technological innovations at the intersection of learning theory and emerging technologies—referred to as "cyberlearning." The goal is simple: All cyberlearning opportunities should be accessible to, usable by, and inclusive of everyone, including instructors and students with disabilities. This paper emerged from a review of relevant literature and ongoing consultation from attendees at an on-site capacity building institute and members of an online community (AccessCyberlearning 2.0, 2019). It serves to inform the design of current and future learning technologies and pedagogy to be inclusive of everyone. To make progress toward this goal, it is recommended that instructors who use digital tools in their courses employ inclusive teaching practices, that faculty members teach about accessibility in computing courses, that researchers address accessibility issues in all stages of their work, and that funding agencies require their funded cyberlearning projects to do the same.

Introduction

Attracting more individuals from underrepresented groups can help meet the demand for science, technology, engineering, and mathematics (STEM) professionals. As stated by the director of the National Science Foundation (NSF), "Science is too important and rewarding to be exclusive, and too vital to the nation's future to leave anyone out" (Cordova, 2017). Those often left out of STEM opportunities include people whose disabilities impact sight, hearing, mobility, learning, social interactions, and other abilities. There is little evidence that inclusive practices are routinely applied to ensure access to STEM for this group (Gladhart, 2010; Harbour & Greenberg, 2017; Kim & Aquino, 2017; Roberts, Satkyjgykyjova, & Park, 2015).

Accessibility in cyberlearning and other learning opportunities is often only considered after a person with a specific disability tries to use the final product and discovers and reports accessibility barriers. This approach can result in expensive and unsatisfactory accommodations.

Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 and its 2008 Amendments mandate that no otherwise qualified person with a disability be excluded from participation in, be denied benefits of, or be subjected to discrimination in public programs. Although institutions that offer on-site and online learning programs are covered entities under this legislation, the US Department of Education Office for Civil Rights receives hundreds of complaints each year regarding the inaccessibility of information technology (IT) used for educational purposes (Office of Civil Rights, 2016). Resolutions to these complaints make clear that the use of inaccessible videos, websites, documents, online learning activities, and other IT resources and tools violates the civil rights of students with disabilities (EDUCAUSE, 2015; Office of Civil Rights, 2016).

The authors of this paper address the following four questions, which additionally serve as the organizational basis for this paper:
1. What challenges do individuals with disabilities face in using cyberlearning tools?
2. What inclusive design frameworks exist to guide cyberlearning research and practice?
3. What are recommendations for cyberlearning researchers that can ensure that digital learning opportunities are accessible to, usable by, and inclusive of students and instructors with disabilities?
4. What are the roles of other stakeholder groups, including instructors and funding agencies, in ensuring that current and future cyberlearning opportunities are inclusive of individuals with disabilities?

Challenges Faced by Individuals with Disabilities

Human beings have diverse characteristics. People who interact with technology include:
- individuals who are blind and use audible (e.g., screen readers that read digital content using synthesized speech) and/or tactile output (e.g., a refreshable braille device);
- individuals with learning disabilities such as dyslexia who use text to speech (TTS) technologies that read aloud digital text while visually highlighting each word;
- individuals with low vision who enlarge default fonts or use screen magnification software that allows them to zoom into the screen;
- individuals with fine motor impairments who use assistive technologies such as speech recognition, head pointers, mouth sticks, or eye-gaze tracking systems;
- individuals in a noisy or noise-free environment or who are deaf or hard of hearing and therefore depend on captions or transcripts to access audio content; and
- individuals who use mobile smartphones, tablets, or other devices, which have a variety of screen sizes, as well as gestures or other user interfaces for interacting with their devices and accessing content.

This list describes only a few of the hundreds of assistive technologies (ATs) and custom configurations that allow individuals with disabilities to effectively use IT. However, full

engagement by this group requires that mainstream IT be designed in accordance with accessibility standards. For example, two technologies already in widespread use to deliver educational content are digital documents and videos. Although both can be created in ways that are accessible to individuals with disabilities, many documents and videos are not.

Digital documents, whether delivered in HTML, PDF, Microsoft Word, or other formats, must be created in particular ways in order to be accessible, especially to individuals using screen readers. For example, it is critical for readers to know whether the text they are reading is a heading, subheading, paragraph, list item, table, footnote, or other structural element. This information is usually communicated visually to sighted readers, but readers who are blind depend on the document being coded in such a way that their screen readers can inform them of the structure. Without such coding, documents are presented to the reader as an unstructured linear stream of text, which can be extremely difficult to parse.

Video content also presents challenges for certain groups of users. Audio content contained within a video is inaccessible to people who are deaf, and to some who are hard-of-hearing, unless the video is captioned. In addition, content that is shown visually, but not described in the program audio, is inaccessible to individuals who are blind. The standard solution to resolve this problem is audio description, a supplemental audio track that describes essential visual content. Even if a video has captions and audio description, it can be inaccessible to many users if it is delivered using an inaccessible media player (e.g., one that cannot be operated without using a mouse). Note that, as for many other specialized features designed for people with disabilities, captions benefit others, including English language learners, people in noisy or noiseless environments, and those who simply want to know the spelling of words spoken in the presentation.

As the complexity of technology increases, so does the potential for introducing barriers for individuals with disabilities. Emerging cyberlearning technologies provide promising opportunities for inclusive learning by offering multimodal representation of information (e.g., embodied interactions or 3D/4D modeling), highly interactive and/or immersive learning environments (e.g., virtual reality and augmented reality), and data science-driven adaptive or personalized learning. However, when designing new technologies, careful thought must be given not only to narrowly-defined intended beneficiaries, but also to individuals for whom the new technologies might erect new barriers.

Inclusive Design Frameworks

Applying proactive design practices can reduce the need for accommodations for specific students after a cyberlearning product or activity is created. There are many practices that employ proactive design: accessible design, inclusive design, usable design, user-centered design, ability-based design, design for user empowerment, design for all, barrier free design, and universal design (UD). Although all offer contributions to the field, UD was selected as the proactive design framework on which to elaborate in this paper because it has led to the most

comprehensive and established principles and practices that can guide the design of inclusive cyberlearning technology and pedagogy. The basic framework is underpinned by the seven principles of UD, the three principles of Universal Design for Learning (UDL), and the four principles of the Web Content Accessibility Guidelines (WCAG), all described in the paragraphs that follow.

UD requires that a broad spectrum of abilities and other characteristics of potential users be considered when developing products and environments, rather than simply designing for the average user and relying on accommodations alone when a product or environment is not reasonably accessible to an individual. UD is defined by the Center for Universal Design (n.d.) as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design." Principles for the UD of any product or environment include the following:

- *Equitable use*: The design is useful and marketable to people with diverse abilities.
- *Flexibility in use*: The design accommodates a wide range of individual preferences and abilities.
- *Simple and intuitive use*: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
- *Perceptible information*: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
- *Tolerance for error*: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
- *Low physical effort*: The design can be used efficiently, comfortably, and with a minimum of fatigue.
- *Size and space for approach and use*: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility. (Story, Mueller, & Mace, 1998, pp. 34–35)

These principles, originally applied to the design of architecture and commercial products, have also been broadly applied to the design of IT hardware and software, later to instruction, and even later to student services (Burgstahler, 2015). A universally-designed space or product, including a cyberlearning environment, is accessible to, usable by, and inclusive of everyone, including people with disabilities. Many UD-inspired frameworks have emerged to specifically address instructional applications. Each is based upon a common finding in educational research: that learners are highly variable with respect to their abilities and responses to instruction. The most common UD-inspired framework applied in K-12 settings is called Universal Design for Learning (UDL). Developed by the Center for Applied Special Technology (CAST), UDL promotes offering students multiple means of engagement, representation, and action and expression throughout the design of all learning activities, as represented below.

- *Engagement*: For purposeful, motivated learners, stimulate interest and motivation for learning.
- *Representation*: For resourceful, knowledgeable learners, present information and content in different ways.
- *Action and expression*: For strategic, goal-directed learners, differentiate the ways that students can express what they know (Center for Applied Special Technology, 2018).

Many specific barriers to digital tools and content faced by individuals with disabilities today have well-documented solutions. These include those articulated by the Web Content Accessibility Guidelines (WCAG), originally published in 1999 by the World Wide Web Consortium (W3C) and most recently updated to WCAG 2.1 (2018). The Guidelines dictate that all information and user interface components must follow the following four guiding principles:

- *Perceivable*: Users must be able to perceive the content, regardless of the device or configuration they're using.
- *Operable*: Users must be able to operate the controls, buttons, sliders, menus, etc., regardless of the device they're using.
- *Understandable*: Users must be able to understand the content and interface; and
- *Robust*: Content must be coded in compliance with relevant coding standards in order to ensure its accurately and meaningfully interpreted by devices, browsers, and assistive technologies.

While the WCAG standards were developed to apply to web-based technologies, their principles, guidelines, and success criteria can also be applied to digital media, software, and other technologies (W3C, 2013).

Applying the combination of UD, UDL, and WCAG principles is particularly suitable for addressing both technological and pedagogical aspects of cyberlearning in order to ensure that students are offered multiple, accessible ways to gain knowledge, demonstrate understanding, and interact. Although the need is minimized with this approach, reasonable accommodations will in some cases still be necessary to ensure full access and engagement to a particular student when the universally designed offering does not already do so. For example, a student with a learning disability engaging in a universally-designed online course may require extra time on an examination as determined by a special education teacher or a postsecondary disability services office.

Cyberlearning technologies and pedagogies that are engaging and effective for all learners result when designers assume that users will have a wide variety of abilities, understand challenges individuals with disabilities often face, and engage in design approaches that result in accessible, usable, and inclusive cyberlearning applications. Specifically, they can apply UD, UDK, and WCAG principles to research-based instructional practices, as illustrated below.

Select research-based instructional practices → Apply UD, UDL, & WCAG principles to research-based practices → Develop best practices for accessible cyberlearning

Even as cyberlearning research pushes the boundaries of current practices, practitioners and researchers can trust that UD, UDL, and WCAG principles will stand the test of time. However,

routinely applying inclusive principles in cyberlearning research and practice requires no less than a paradigm shift from designing for some to designing for everyone.

Recommendations for Research and Practice

The *Cyberlearning Community Report: The State of Cyberlearning and the Future of Learning with Technology* published by the NSF-funded Center for Innovation Research in CyberLearning (CIRCL), includes examples of cyberlearning research (Roschelle, Martin, Ahn, & Schank, 2017). Consistent with other literature, there is little indication in the document that accessibility of learning environments to instructors or students with disabilities is routinely explored; twice it is mentioned that cyberlearning technologies have the potential to extend educational opportunities to students or investigators with disabilities, but without further explanation.

Two lines of research can make important contributions to the cyberlearning field: (1) building products and pedagogy that benefit individuals with specific disabilities and (2) creating mainstream cyberlearning products and pedagogy that are accessible to all students, including those with a wide range of disabilities. Examples of cyberlearning research in each of these categories were shared by participants at the *AccessCyberlearning 2.0* capacity building institute (2019). Examples in the first category include research projects focusing on specialized technologies designed to enhance education for students with vision impairments, students who are deaf, and students with a low neurological threshold for sensory input. Most examples of research in the second category are related to design practices that make an online learning course more inclusive of students and instructors with a wide range of abilities with respect to seeing, hearing, moving, and learning.

Additional research is needed in both areas. In particular, cyberlearning researchers are encouraged to pursue research in both learning science and technology design that specifically addresses the unique needs of individuals who have a wide variety of abilities and other diverse characteristics. Research is needed to solve accessibility problems that exist with current technologies and to harness emerging technologies into solving accessibility challenges. Cyberlearning researchers are also encouraged to evaluate accessibility implications of current and emerging cyberlearning technologies, including those described in the Cyberlearning Community Report. Researchers could explore how each design might be inaccessible to students with a variety of disabilities and what additional research, design, or development is needed in order to address the accessibility problems revealed. Also, research is needed that helps to reduce the cost of accessibility implementation so that it can be more feasible on a large scale (e.g., by automating the creation of accurate alternative text for images and captions for videos).

In addition to identifying specific areas of research focus, recommendations for cyberlearning researchers emerged from a literature review, current practices, and presentations and discussions in the *AccessCyberlearning 2.0* capacity building institute (2019). Participants in the project agreed that cyberlearning opportunities should be made available to all potential students, including those with disabilities. However, tensions arose with respect to how much effort toward accessible design researchers should be required to make at different stages of prototype development and how researchers can gain the expertise they need to do so.

Participants considered whether new design principles are needed, but came to the conclusion that it's less about new principles and more about ensuring that the technologies of the future are designed with today's principles and best practices in mind. They also acknowledged a need to apply accessibility principles in developing guidelines and practices for specific cyberlearning types. Most agreed that getting more researchers to routinely consider accessibility in their work will be difficult. The recommendations listed below were supported by many of the project collaborators. They are organized into two groups: Those that can be implemented immediately in existing projects and products, and those that can be implemented in the future.

Recommendations for Immediate Actions

Immediately, cyberlearning researchers should
- become familiar with the UD, UDL, and WCAG principles and established guidelines and practices they support as they apply to the design of inclusive cyberlearning tools and pedagogy;
- explore how cyberlearning practices supported by the science of learning can be overlaid with UD, UDL, and WCAG principles to make them inclusive of individuals with disabilities;
- invite someone with IT accessibility knowledge to be a member of their research teams;
- ensure project staff are trained on basic accessibility principles and standards-compliant coding practices;
- establish internal policies and guidelines for accessibility within their projects, and, if relevant, their departments or institution;
- consider a broad range of learning styles and disability types during the earliest phases of conceiving and designing a project;
- analyze the experiences of participants with different types of disabilities along with other demographic groups when reporting research results; and
- when reporting limitations of their studies, include accessibility limitations.

Recommendations for Future Actions

In the future–both in near-term (i.e., 1-3 years) and longer term (3-5 years) timeframes–cyberlearning researchers should develop and promote practices related to the following suggestions that fully embrace disability-related considerations into their research workflows. They should
- implement an agile, iterative design process that involves users with a wide variety of disabilities and other human characteristics in all phases of the research and design process;
- actively participate in collaboration and communication among academia and industry on issues pertaining to the accessible design of cyberlearning;
- contribute to the development and sharing of guidelines for accessible design of cyberlearning tools and pedagogy;
- avoid being deterred by cost. Low-cost interventions can provide great benefits to users. On the other hand, early designs of innovative technologies may be quite expensive, but long term, if widely adopted and/or if adjustments are made to the design, the cost per user can drop significantly;

- articulate the broad characteristics of potential users in the design of a tool or pedagogy being developed or studied, and specify how the characteristics of various groups of individuals with disabilities will be addressed in the research design;
- resist generalizing all people who share a specific disability when designing technology to improve access for a population—for example, designing something to improve access for people who are blind should consider that not all people who identify as "blind" have the same vision capabilities or personal preferences for learning. Technology design should allow the user to customize their experience;
- if instructor guidelines will be created as part of the study, share information about accessibility issues for students with disabilities, including how some activities/products developed in the project may not be accessible to certain groups (e.g., students who are blind) along with suggested accommodations that might be provided (e.g., working with a sighted person); and
- integrate accessibility recommendations into existing project management practices to keep them on the forefront, rather than being an afterthought. Doing so will allow accessibility to be addressed as an integrated part of the project.

Roles of Stakeholder Groups

In order for cyberlearning to be effective for all students, including those with disabilities, many stakeholders need to be involved individually and work together toward a common goal. Roles of various stakeholder groups in supporting positive change are suggested in the paragraphs that follow.

- *Researchers*: The availability of inclusive cyberlearning technology and practices will increase if cyberlearning researchers routinely include individuals with disabilities and accessibility considerations within every phase of their design, development, and evaluation processes, as described throughout this paper.
- *Students with disabilities and their allies*: Students who report accessibility barriers for themselves and/or others with respect to a cyberlearning activity can encourage instructors to design more accessibly, especially when they not only register a concern, but suggest a solution.
- *Cyberlearning designers and instructors*: Cyberlearning practitioners can apply practices supported by the science of learning overlaid with UD, UDL, and WCAG principles and related guidelines and practices throughout their course development workflows. They can ensure that all tools used for online learning are tested and verified for accessibility and work around inaccessible features, perhaps in collaboration with disability service personnel through accommodations for specific students with disabilities.
- *Instructors of K-12 and postsecondary computing courses*: The creation of more accessible cyberlearning tools of the future can be promoted when those who teach computer science and other IT-related courses include in their curriculum topics regarding IT access issues for individuals with disabilities, including barriers that are erected by IT, and how they can be avoided through standards-compliant and other inclusive design practices.

- *Makerspace, engineering lab, and other learning facility managers*: Individuals in positions to design and manage learning spaces, as they make design decisions, can take into consideration the wide variety of characteristics that potential users of the space might have.
- *Disability services staff*: Disability services staff should be responsive to requests for accommodations from students with disabilities and provide reasonable accommodations that give them access to courses or other cyberlearning activities in a timely manner. In their interactions with faculty and designers, they can encourage the application of inclusive technologies and teaching practices.
- *Educational administrators and other leaders*: Educational leaders at all levels who value diversity, equity, and inclusion can ensure that policies and processes in all areas of the organization reflect this view by proactively addressing potential access issues for individuals with disabilities. Specifically, they can implement policies, guidelines, and procedures related to accessibility, as well as ensure that sufficient staffing, training, and resources are available to support these efforts.
- *Personnel who procure cyberlearning products*: To ensure that institutions meet their legal and ethical obligations for access, procurement administrators can put processes in place for those who procure IT and related products and services to ensure that cyberlearning technologies are tested and verified for accessibility prior to purchase and deployment.
- *Technology companies*: To develop expertise within IT companies, company leaders can include accessibility knowledge and skills among the qualifications in job announcements, and demonstrate a preference for hiring people who meet these qualifications. They can also offer training opportunities to current staff and encourage colleges and universities to teach about accessibility in computing courses.
- *Funding agencies*: Agencies that fund cyberlearning projects can require those projects to develop technology and pedagogy that is accessible to individuals with disabilities. Funded projects could be required to design prototypes and project products that comply with WCAG, apply UD principles to on-site and online environments, incorporate UDL practices in learning activities, and share in project reports and published articles the participation and experiences of individuals with disabilities. In cases where innovative designs are in early stages of development and there are not enough resources to make the designs fully accessible, projects should, within their reports and published articles, recommend future research that would address accessibility issues.

Conclusions

As a wide range of digital technologies become more abundant in formal and informal learning opportunities, the need to make technological innovations and pedagogical practices more inclusive of potential students and instructors with disabilities is critical. This paper reveals key information for creating accessible cyberlearning.

- US civil rights legislation requires that students with disabilities have access to educational opportunities, including opportunities that make use of IT;
- There is little evidence that cyberlearning technology and pedagogy research and practice routinely address access issues for individuals with disabilities.

- Established principles, guidelines, and practices currently exist to guide the development and use of accessible, usable, and inclusive cyberlearning technology and pedagogy.
- Some accessible design practices that focus on disabilities benefit other groups as well.
- To achieve systemic change toward more inclusive cyberlearning, it is important that researchers, instructors and course designers, computing faculty, IT companies, funding agencies, and other stakeholder groups be engaged.
- Stakeholders need training and resources tailored to their particular roles in ensuring that future cyberlearning innovations are more inclusive of individuals with disabilities.

The ideal state for future cyberlearning research is that researchers routinely include individuals with disabilities and accessibility considerations within every phase of research, design, development, and evaluation processes. Reaching this goal requires a paradigm shift from designing for some to designing for everyone.

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