Best Practices for Teaching Accessibility in University Classrooms: Cultivating Awareness, Understanding, and Appreciation for Diverse Users

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As Information and Communication Technologies (ICTs) become more diffuse, developers and designers need to consider a growing diversity of users including people with disabilities and aging populations. As a result, computing education needs to respond by providing students opportunities to learn about accessibility and designing for inclusion. This article presents results of a qualitative research study of practices in teaching accessibility in university-level programs in the US. The study included interviews with 18 professors from some of the top universities in the US and a content analysis of syllabi and other teaching materials. Using the pedagogical theory of authentic learning and elements from the 21st Century Skills framework, we found that instructors emphasized the need for students to develop awareness and understanding for a diversity of ICT users through multiple different experiences; experiences that included research projects that directly involve users with disabilities, guest speakers, field trips, simulating disabilities, and the use of videos/movies. Additionally, instructors used multiple resources (e.g., research papers, online resources), in part, to offset the challenge that there is a perceived lack of a comprehensive textbook. Instructors also emphasized the importance of their individual initiative; that is, the inclusion of accessible topics or courses was often linked to a faculty member's research and/or personal commitment. This article contributes to a gap in the literature by disseminating and sharing different approaches to teaching accessibility across multiple instructors, courses, and campuses.

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1. INTRODUCTION

As Information and Communication Technologies (ICTs) become more diffuse, the diversity of users that developers and designers need to consider is growing; this includes people with disabilities and aging populations. As a result, computing education needs to respond by providing students opportunities to learn about accessibility and designing for inclusion. In this article, we present findings from 18 interviews with professors from some of the top universities in the US who discussed their experiences teaching courses and topics related to accessible computing. We also include findings from a content analysis of syllabi and other teaching materials provided by a subset of the instructors ($n = 11$). This article contributes to a gap in the literature on teaching accessibility by disseminating and sharing different approaches that synthesize findings from multiple instructors, courses, and campuses. In the next sections, we expand on the motivation for this article, discuss relevant pedagogical theories/frameworks, and related literature.

1.1. Motivation

Creating accessible ICTs is important for many reasons, including access and entry to areas of employment, education, and recreation previously closed to people with disabilities [Henry et al. 2014; Schur et al. 2005]. Additionally, creating accessible ICTs is necessary to accommodate growing elderly populations [Hansen 2001]. In this section, we provide additional detail on the legal requirements of accessible ICTs and a growing call for computing educators to prepare the next generation of system designers and developers to have knowledge of accessible computing.

In many countries, including diverse users has important legal considerations for companies who are obliged to comply with accessibility requirements in the design of ICTs. For example, in the United States, Section 508 of the Rehabilitation Act of 1973 (modified in 1998) requires that all information technology funded by federal agencies be accessible for people with disabilities [United States Access Board 2015]. Additionally, the Americans with Disabilities Act (ADA) requires that a "place of public accommodation" must be accessible for people with disabilities. In 1996 the US Department of Justice ruled that the Internet is such a public place [Stowe 2000]. In 2011, President Obama signed the 21st Century Communications and Video Accessibility Act (CVAA), which expands the legal obligations for providers of advanced communications services to include video captioning for people who are deaf, video descriptions for people who are blind, and access to user guides and menus (e.g., for televisions shows, DVDs, etc.) for all people with disabilities. Many similar laws are also in place in Europe, Canada, and Australia [Lazar et al. 2015].

Due to the increased importance and legal requirements for creating accessible ICTs, people in ICT industries have also called for more emphasis on accessibility. For example, Larry Goldberg, the Director for Accessible Media at Yahoo! called for the presence of accessibility knowledge in job requisition language in Yahoo!'s "Job Descriptions Initiative" [Goldberg 2015]. Several other ICT companies have joined Yahoo! in this initiative, including Adobe, Facebook, and Microsoft [Teaching Accessibility]. Additionally, Goldberg is working to encourage university and industry partnerships to create models for teaching and training students in how to consider diverse users.

As such, organizations that educate ICT professionals have an increasingly greater obligation to include topics and/or courses that focus on inclusionary practices to prepare students for professional careers. Recognizing this obligation, in May 2014, Maryland (USA) passed a law (SB 446/HB 396) to improve the teaching of accessibility concepts. The Maryland Department of Disabilities (in cooperation with the National Federation of the Blind) is studying how accessibility concepts are taught in ICT-related

higher education programs in the state, with the goal of identifying problems and gaps in how accessibility is taught [Turner 2015]. The study involves several academic institutions in Maryland, including Morgan State University and St. Mary's College of Maryland.

In addition, several authors in academia have also argued for the importance of teaching of accessibility-related topics in ICT curricula [see, for example, Waller et al. 2009; Lazar 2002; Rosmaita et al. 2006]. Bohman [2012] contended that allowing students to graduate without exposure to topics on ICT accessibility perpetuates "the cycle of ignorance among ICT developers and maintains the status quo of exclusion and marginalization of people with disabilities who cannot use the inaccessible products created by the ignorant developers" [Bohman 2012, p. 5].

Further, the importance of accessibility is recognized by professional organizations in computing. The ACM and the IEEE Computer Society through the Joint Task Force for Computer Science Curricula [2013] (CS2013) identified the topics of "Accessibility" and "Interfaces for differently-aged population groups" as foundational to include in Human-Computer Interaction (HCI) courses. To be clear, however, the topics were not identified as foundational for Information Systems or Information Technology curricula.

While there is a recognized need to include principles of accessibility in computing education among industry leaders, law makers and academics, there is a lack of shared resources for instructors with little or no background in the area to help them incorporate these topics into their curricula. In an effort to meet this need, the "Accessing Higher Ground," a conference held annually in Colorado, includes speakers focused on accessibility education [Accessing Higher Ground 2015]. Howard Kramer, a lecturer at the University of Colorado, cofounded the conference. The central theme of the 2013 conference was focused on teaching accessibility-related topics. Our team was similarly motivated to conduct this study in order to help ICT instructors in higher education incorporate accessibility in their courses and programs.

While other articles have provided small-scale surveys or first-person reflections about teaching accessibility, there has been little research that looks across a larger number of instructors, courses, practices, materials, and programs in order to synthesize current practices; this article contributes to bridging this gap. The article is organized as follows. First, we discuss pedagogical theories/frameworks that we used to synthesize our findings and summarize related academic literature. Second, we detail the study methods. Third, we present combined findings from the interviews and content analysis of syllabi and other teaching materials. Fourth, we invite discussion on how to move forward with sharing information and creating new resources in teaching accessibility. We conclude with two synthesized syllabi that exemplify the findings in an appendix.

1.2. Pedagogical Theory/Framework

To situate this research within educational literature, two theories/frameworks informed our analysis. We first considered the pedagogical theory of "authentic learning" because, as others have noted, it is particularly well suited for computing education [Shaffer and Resnick 1999]. From a meta-analysis of literature on authentic learning, Shaffer and Resnick identified four interdependent and mutually supporting aspects of pedagogy that they defined as effective "thick" authentic learning. Authentic learning instruction should emphasize (1) means to cultivate personal meaning for students; (2) relationships to the real world outside school; (3) means of assessment that reflect the learning process; and (4) opportunities for students to think about the topic(s) in multiple ways.

The first two points are interrelated in that both are concerned with teaching content that reflects "real-world" contexts and subjects. The measure of "personally meaningful" is based on student perception of learning activities as being "real" or "work they can honor." To the second point, to help cultivate student meaning, it is important to include real-world activities that generalize outside of school. One example the authors cited was a use of comic books to teach a foreign language [Williams 1995].

In an authentic learning assessment, instructors are expected to make student evaluations part of learning activities and within the context of the topic being taught. For example, student presentations and portfolios of work are considered authentic learning assessment tools because of their emphasis on having students actively engaged in tasks where learning is an integral component. In other words, tests can also be an authentic assessment, as long as students learn about the topic while taking the test.

Projects such as this article are meant to generate ideas and present multiple ways of looking at the same topic, putting projects like this in the fourth category/emphasis of authentic learning. These projects are good conduits to help instructors learn and share ideas that consider different approaches to teaching a topic. Events, such as the Accessing Higher Ground conference, are also excellent venues for sharing and generating discussion.

While our primary theoretical lens for synthesizing our analysis was authentic learning, this research also leveraged aspects of the 21st Century Skills framework. This framework focuses on teaching students skills that will be required in the 21st century [Trilling and Fidel 2009]. The framework, developed with input from multiple sources that included educators and business leaders, focuses on student outcomes in four categories: (1) content knowledge, for example, health literacy; (2) learning and innovation skills, for example, critical thinking; (3) life and career skills, for example, cross cultural awareness; and (4) information, media, and technology skills, which includes ICT literacy [Partnership for 21st Century Skills 2011]. ICT literacy is discussed in terms of communicating and collaborating with people from diverse groups and in terms of doing ICT-related research. While accessibility is not explicitly discussed as part of the framework, we argue that it extends to teaching accessibility in computing courses because of the framework's emphasis on collaborative research, technology, and diversity.

In summation, authentic learning, combined with ICT literacy concerns of the 21st Century Skills, emphasizes three approaches that were evident in the literature review and in the research findings: (1) prominence of real-world learning environments to help make accessibility topics personally meaningful for students; (2) exposing students to accessibility topics in multiple ways; and (3) providing opportunities for students to work on collaborative teams focused on ICT research that often included people with disabilities.

1.3. Related Work

While we recognize the importance of related work focused on making higher education more accessible for students with disabilities (e.g., Burgstahler and Cory 2010, Access Computing Knowledgebase), in this review we concentrated on work focused on *teaching* accessibility-related topics in higher education. We organized this related academic work into two categories. In the first, and most similar to this project, we included studies that examined multiple programs or courses across multiple institutions. In the second category, we included a review of first-person reflective papers written by instructors describing their experiences and approaches to integrating accessibility topics into their courses.

1.3.1. Studies Examining Multiple Programs or Courses across Multiple Institutions. The most extensive work in this area is Bohman's doctoral dissertation [Bohman 2012], which investigated how accessibility was taught in three distinct Master of Science (MS)

degree programs. The three programs included (1) MS in Instructional Technology at George Mason University in the US; (2) MS in Digital Inclusion at Middlesex University in the UK; and (3) MS in Web Sciences at the University of Linz in Austria. As case studies, the scope of his investigations was narrow but deep; he focused on histories, the processes, and the rationale for the development of the accessibility-related curricula and the structure of the curricula.

In his analysis, Bohman details differences in approaches for including accessibility within a program. The George Mason University program simply included a required course focused on accessibility. Conversely, the MS in Digital Inclusion at Middlesex University was designed as a stand-alone program that focused exclusively on the design of ICTs through the lens of accessibility. Similarly, the University of Linz program (first called "Barrier-Free Web Design") was focused on training people to create accessible web designs [for more, see Miesenberger and Ortner 2006]. The intent of the latter two programs was to produce accessibility specialists. However, neither program survived over the 2 years of Bohman's project due to a lack of enrollment. Bohman suggested that the closing of the two latter programs implied that the perceived need for university-trained accessibility experts had not yet reached a level to sustain dedicated programs. Since the dissertation's publication in 2012, the University of Linz program changed their approach and had integrated accessibility throughout their web sciences curriculum. A key takeaway from Bohman's work was the pivotal role of accessibility champions in the development of these programs and curricula; in other words, the programs and curricula were the efforts of a few dedicated instructors who had expertise in accessibility. An additional takeaway from Bohman's work is the challenge of sustaining stand-alone accessibility programs.

In another study that examined accessibility across multiple programs, researchers conducted a survey among partners of the European Design for All eAccessibility Network [EDeAN 2007]. Established in 2002, the EDaAN's aim was to raise the awareness of Design for All and included 160 partner organizations in the EU. In the study, project partners within the EDaAN were contacted through e-mail to provide information about how accessibility-related training and teaching was being addressed [Keith et al. 2009; Keith and Whitney 2008]. The authors gathered information about 50 courses from 35 course providers that addressed accessibility in some way; courses were designed for a mix of vocational, professional, and university-level (undergrad and graduate) programs. They found that two activities were reported as having the most impact on students—both were those from authentic learning concepts: (1) engaging students in practical real-world applications (e.g., designing an accessible website); and (2) making the concepts personally meaningful for students through demonstrations of ICT use by people with disabilities through invited talks or videos.

1.3.2. First- Person Reflective Papers by Instructors Describing Their Own Experiences. In this category of related academic literature, we included first-person accounts that were written by instructors who taught and/or created courses or programs concerned with accessibility. While we are aware there are a variety of first-person accounts on teaching accessibility, in this review we have included a subset of articles that represented the range of how instructors have included accessibility into computer science curricula. We organized these papers based on how accessibility was integrated into the curriculum: (a) systematic integration of inclusionary thinking throughout an entire computer science program; (b) integration of accessibility-related topics throughout a single course; (c) accessibility-related modules (1–2 weeks) included as part of a larger course; and (d) stand-alone courses.

1.3.2a. Systematic Integration of Inclusionary Thinking throughout an Entire Computer Science Program. Several authors have argued for systematic integration of accessibility thinking throughout ICT curricula. For example, Rosmaita [2006] argued

for the inclusion of accessibility topics throughout programs focused on web design, suggesting that, "All aspects of web design should be taught from the standpoint of how they contribute to accessibility" [Rosmaita 2006, p. 272]. Similarly, Petrie and Edwards [2006], researchers from the University of York in the UK, argued that accessibility considerations should be discussed in all HCI courses. They contended that accessibility is innately linked to HCI education because it forces students to consider the diversity of users (different than themselves) that they will need to consider as ICT professionals.

In an example of a first-person(s) account of an integrated program, Waller et al. [2009], from the University of Dundee in the UK, discussed how accessibility topics were included throughout their entire 4-year curriculum for undergraduate ICT students. In the first 2 years, students were exposed to accessibility considerations through modules in required Computer Science (CS) courses. In the third and fourth years, students were involved in both (a) projects in which diverse users are considered and (b) took stand-alone courses focused on accessibility-related topics. In alignment with authentic learning, the program provided multiple ways, including practical real-world assignments, for students to engage in accessibility topics. The authors also described how the emphasis on accessibility in the program was beneficial beyond the curriculum integration, that is, how awareness of accessibility was raised across the university, which resulted in the university's web developers making the website more accessible.

1.3.2b. Integration of Accessibility throughout a Single Course. There are several examples of educators describing courses in which they integrated accessibility-related topics throughout the course. For example, Wang [2012] provided detailed information about her effort to integrate accessibility topics through eight lectures as part of a web design course at George Mason University. In addition to introducing several successful activities—for example, use of a short video from WebAIM in which six students with various disabilities share some of their experiences with the Internet and accessibility [see Smith 2012]—Wang outlines week-by-week accessibility topics, assessment rubrics, and sample assignments.

A common theme in papers in this subcategory was the importance of including videos and/or direct interaction with users with disabilities. In alignment with authentic learning, these activities were aimed at making the subject matter meaningful to students and providing real-world experience. In an example, Kurniawan et al. [2010] described a general education undergraduate course they created and taught. The course was somewhat unique in the related literature, because it was not aimed at computing-related majors. The general audience forced the authors to use a variety of approaches that were understandable and relatable to a wide range of students; their approaches included videos and direct interaction with end users. Related, Carmichael et al. [2007] described instructional videos they created that portrayed the use of technology by older adults. In the project, the authors presented the videos to two groups: (1) a first-year class of Applied Computing undergraduates ($n = 40$) and (2) HCI professionals and academics attending a workshop on people who were elderly at the HCI 2004 conference ($n = 51$). They found through a questionnaire that the videos had a significant impact on raising awareness of the need to consider people who are elderly in the design of ICTs.

Ludi [2007] also discussed the importance of direct interaction with end users who have disabilities. In her paper, she discussed an undergraduate software engineering course where students worked in collaborative groups on a project-based assignment where they were required to include accessibility considerations. While all student groups interacted with external stakeholders, one group interacted with a software developer who was blind. Ludi found that the resulting project from the latter student

group did a better job integrating accessibility features compared to the student groups who did not have an external stakeholder with disabilities. This is an excellent example of an empirical measure used to support the need for direct interaction with end users who have disabilities.

In another example of an effort to empirically measure the effect of introducing accessibility-related topics, Poor et al. [2012] discussed their experience integrating accessibility requirements into a project required for an existing HCI course at Bowling Green State College. Through a survey containing 65 questions, students were asked to rate the importance of several aspects of computing (one was an accessibility-related question). The authors assessed (a) baseline student attitudes toward computing (including users and accessibility) and (b) how attitudes changed after being involved in a project-based HCI course that required students to consider accessibility. They found that students rated the importance of (a) broadening the range of users they need to consider and (b) designing and building web interfaces as significantly more important after the course. The authors concluded that exposure to accessibility topics significantly raised student awareness. While the results may not be particularly surprising, it is one of the few empirical studies to examine the relationship between learning outcomes and accessibility topics.

Lazar [2011] discussed lessons learned integrating community-based projects as part of an HCI course he taught at Towson University; some of these community-based projects were accessibility related. Key takeaways of managing collaborative group projects that we felt were especially helpful to readers of this article included the following: (a) involve highly dedicated community partners in the course; (b) it is critical to provide clear roles, responsibilities, and deadlines for both students and community partners; (c) first look to existing university community service groups for partners; (d) focus on learning goals and not necessarily successful project outcomes because not all projects will be successful; and (e) students need help with managing their projects, including setting milestones.

1.3.2c. Accessibility Module Included as Part of a Larger Course. A common approach to teaching accessibility is to add modules in existing courses—most were HCI courses. Harrison [2005] describes including screen-reader technology in a web design course at the University of Wisconsin-Eau Claire. In a good example of making topics personally meaningful for students, she included labs in which the students had to try to interact with web sites using a screen reader. This was followed by a screen-reader demonstration by speakers who were blind.

Martin-Escalona et al. [2013] outlined an accessibility module she taught in an introductory engineering course. The course was a requirement for five different engineering-related programs at the Technical University of Catalonia. There were two parts to the learning module: (1) lecture and (2) practical sessions that afforded student collaboration on team projects. While the authors reported that the accessibility module has been successful, one challenge they encountered was related to the range of students' interest and background across the five different engineering programs, which resulted in difficulties in collaborative projects. The authors recommended instructors be mindful of diverse student backgrounds and the need to customize their instruction to meet that diversity.

Benavidez et al. [2006] discussed their experiences incorporating accessibility in web design courses at Sidar Foundation and the Technical University of Madrid. For the course, the authors created (and shared) two sets of training materials: (1) Contromano and (2) HERA. Contromano was a fictitious website with accessibility and usability mistakes paired with a "corrected" site. The two sites were aimed at helping instructors demonstrate accessibility errors to students; HERA was an online tool

the authors created to evaluate websites based on Web Content Accessibility Guidelines (WCAG) standards. While at the time of this writing the websites discussed in this article are somewhat out of date, the use of example before and after accessibility considerations is yet another example of providing students with authentic learning experiences based in real-world settings; since the publication of this article, other organizations have published before and after examples, including the W3C (e.g., http://www.w3.org/WAI/demos/bad/).

1.3.2d. Stand-Alone Courses. First-person accounts of stand-alone ICT courses focused on accessibility-related topics were not common in the literature; in fact, we only found one. In a two-page extended abstract, Liffick [2005] describes her course focused on the design and development of Assistive Technologies (ATs), such as augmentative/alternative communication devices. In an example of making ATs personally meaningful, students actively interacted with various ATs in a lab she created to support the course. One challenge she discussed was the high expense of ATs and the related difficulties in keeping an AT lab up to date.

1.3.3. Related Work Summary. To summarize this section on related work, successful approaches to teaching accessibility have used concepts from authentic learning while emphasizing aspects of 21st Century Skills. There has been a wide range of approaches to integrating accessibility topics in computing education: (a) stand-alone programs (e.g., the MS in Digital Inclusion at Middlesex University in the UK); (b) integration of accessibility throughout an entire CS program (e.g., University of Dundee); (c) as a stand-alone course (e.g., George Mason University); (d) integration of accessibility throughout a specific course (e.g., Bowling Green State College); and (e) as a module or part of a larger computing course (e.g., University of Wisconsin-Eau Claire). Several authors discussed ways to make topics personally meaningful for students through activities that include videos [e.g., Wang 2012], labs [e.g., Harrison 2005], and direct interaction with people who have disabilities [e.g., Ludi 2007]. Additionally, it was common for instructors to assign projects that required student and/or client collaboration that provided a means for students to experience accessibility topics in real-world environments outside of school [e.g., Lazar 2011]. Martin-Escalona et al. [2013] also highlighted the challenges of teaching accessibility to students in computing education because of their diverse foci and backgrounds. All of these contributions were aimed at improving pedagogy of accessibility; we were similarly motivated to conduct this exploratory study but wanted to collect a wider variety of instructor insights and experiences across programs.

2. METHODS

In this section, we discuss the details of the study, including the participants (2.1), protocol (2.2), and data analysis (2.3). The research protocol for this study was reviewed and approved by the Institutional Review Board at DePaul University. Each participant was given the option of having his or her name and affiliation made public or remaining confidential. Each participant was also given the opportunity to review and grant permission for us to use and attribute the specific quotes that appear in this article.

2.1. Participants

To identify instructors who teach accessibility, we started with the list of the top 160 US universities published in the US News and World Report. Next, we visited each school's webpage and searched for a course catalog, which we typically found under "academics," "students," or "register." We then used a two-step approach to search for courses related to ICT accessibility: in step 1, we identified departments and/or programs related to computing (HCI, CS, Interactive Media, Media Studies, Software

Engineering, Information Systems, Information Technology, Communication, Network Engineering, and Computing); and in step 2, we searched for keywords in the course descriptions in those departments/programs (access, accessibility, assistive, barrier-free, design for all, disability, human factors, inclusive, inclusion, eInclusion, section 508, universal access, usability, user-centered). If keywords were found, we identified the course, course number, last or current instructor to teach (if possible), and then contacted that instructor through e-mail. If no keywords were found, we identified and contacted either (in this order) (1) the department chair, (2) the last instructor to teach an introductory computing class, or (3) the administrative assistant of the department.

In addition to searching the top 160 US universities in the US News and World Report list, we also identified other leads through the literature review and by convenience sampling, meaning during the interviews we asked our participants to refer us to other instructors who taught accessibility. These follow-up leads were either from the original contact's university or other universities including some not on our original list. As a result, the data include a subset of schools ($n = 5$) where we had multiple participants. We also cross-referenced the literature review, finding published articles from universities that might not have been in the listed top 160, but where instructors had published on the topic of accessibility. This added an additional 11 universities to our contact list.

Individuals from the contact list were sent an e-mail in April 2014. In total, we contacted 236 people; 38 individuals replied with one or more of the following responses: (1) agreement to an interview, (2) a polite "no thank you," and/or (3) suggestions for other contacts. In the contact e-mail, potential participants were given an option for a phone interview or an e-mail interview (we later also converted the e-mail interview to a survey form to simplify the process for participants). Twenty-one people agreed to an interview; 11 opted for a phone interview, seven for an e-mail interview/survey, and three never responded after one reminder, resulting in 18 completed interviews. All interviews were conducted in April and May, 2014. In the interviews, we asked for syllabi when available. And while we did not specifically request other supporting course materials, some interviewees offered (e.g., lecture slides). In total, 11 participants provided additional course materials that included lecture slides and syllabi; we performed a content analysis on those materials.

While most participants taught in Computer Science programs ($n = 12$), several taught in other programs related to CS including Information Technology (IT), Industrial Systems and Engineering, Information Systems (IS), Human-Centered Design and Engineering (HCDE) and HCI. See Table I for the list of participants and their affiliations.

2.2. Interview Protocol

After agreeing to consent, participants were first asked if accessibility topics were incorporated into multiple courses in their programs. Accessibility topics were defined as inclusion of diverse users that included elderly and/or people with disabilities. If they answered that they did include accessibility topics, we asked about the percentage of courses in the program that included related topics and to describe the courses.

We then asked if they taught a course focused solely on accessibility (as defined earlier). If they answered yes, we asked about course details, including the name of the course, the course level (e.g., undergraduate), when last taught, how long the course had been offered, how often the course was offered, and if the course was a requirement or elective. We also asked the instructor to share syllabi, and if it was not available we asked about the course content including (a) learning goals and objectives, (b) major topics covered, (c) major assignments, and (d) textbooks and readings. Next, we asked

Table I. Participant List

Participant (A–Z)	Title (5.2014)	Institution (5.2014)	Primary department/ affiliation	Other course materials?
Dan Cosley	Associate Professor	Cornell University	Computer Science	No
Katherine Diebel	Instructor	University of Washington	Computer Science	No
Jinjuan Heidi Feng	Associate Professor	Towson University	Information Systems	No
Krzysztof Gajos	Associate Professor	Harvard University	Computer Science	Yes
Juan Gilbert	Professor	Clemson University (Now at University of Florida)	Computer and Information Science–Human-Centered Computing	No
Derek Hansen	Associate Professor	Brigham Young University	Information Technology	Yes
Amy Hurst	Assistant Professor	University of Maryland, Baltimore County	Information Systems	Yes
Julie Kientz	Assistant Professor	University of Washington	Human-Centered Design and Engineering	Yes
Sri Kurniawan	Associate Professor	University of California Santa Cruz	Computational Media and Computer Engineering departments	No
Richard Ladner	Professor	University of Washington	Computer Science	No
Clayton Lewis	Professor	University of Colorado	Computer Science, Human-Centered Computing	No
Benjamin Lok	Professor	Northeastern University(Now at University of Florida)	Computer and Information Sciences and Engineering Department	No
Bilge Mutlu	Associate Professor	University of Wisconsin, Madison	Computer Science, Director of the HCI laboratory	Yes
Steven Reiss	Professor	Brown University	Computer Science	Yes
Seth Teller	Professor (Deceased)	Massachusetts Institute of Technology	Department of Electrical Engineering and Computer Science	Yes
Gregg Vanderheiden	Professor	University of Wisconsin	Industrial and Systems Engineering	Yes
Confidential	Confidential	Private Northeast University	Confidential	Yes
Confidential	Confidential	Private Northeast University	Confidential	Yes

if they taught a module or topic focused on accessibility as part of a larger course. If yes, we asked them to provide the same details as we did for a dedicated course.

If the participant had some teaching experience in accessibility-related courses or topics we followed with a discussion about their experience. Specifically, we asked about (a) activities and/or assignments that had been particularly successful, and to explain why; (b) a memorable experience with a class and/or student(s); and (c) if they were to run into a former student what would they like to have had the student recall about the course. If applicable, we also asked about how they included their research in their

teaching. For the telephone interviews, we also asked participants what they would like to take away from our research. Finally, we asked if they would like to keep their information confidential; 16 of 18 gave us permission to attribute their quotes in this article.

2.3. Analysis

2.3.1. Interviews. After the interviews were transcribed, two members of our research team conducted an inductive analysis and created five overarching theme areas that contained 33 subcategory areas. We then cowrote a codebook on how to identify those themes and subcategories. Two other members of our team who were not involved in the codebook creation coded the interviews using the codebook. We then calculated inter-rater reliability using Cohen's Kappa through binary agreement with those coders (i.e., was a theme apparent in the response, yes/no). All five overarching themes were supported with at least one subcategory area that resulted in a Cohen's Kappa rated at "good" agreement (0.60) or greater. Among the 33 subthemes, 18 had at least a "good" agreement. In this article, we have included discussion of all the overarching themes and emphasized subcategories that had a "good" or better agreement.

2.3.2. Content Analysis. Two researchers from our team conducted a content analysis of course materials provided by 11 of the interviewees. There were a total of 29 documents; we were able to extract meaningful data for this article from 21 documents that were made up of 14 sets of lecture slides, five syllabi, and two lab descriptions. Among the 14 lecture slides, four were focused on web accessibility and 10 on ATs. Three of the syllabi were from stand-alone courses; two were from courses that included web-based accessibility considerations. The two assigned researchers examined the documents separately and then collaboratively created a set of themes found in the materials. Their themes were informed by the coding themes in the interviews.

2.3.3. Synthesis. Last, one member of our team took the themes from both the interviews and content analysis and organized them through the lens of the pedagogical theory of authentic learning and the 21st Century Skills framework when they were applicable. We also used the synthesized findings to create two sample syllabi (see Appendix) for (1) 1–2-week module for web-based considerations in a larger HCI or web design course; and (2) a stand-alone course taking 11–15 weeks.

3. FINDINGS

All 18 interviewees told us that accessibility-related topics were taught in at least one course in their programs. Three interviewees felt that accessibility was systematically integrated into multiple courses in a degree program, namely, (1) Information Systems (IS) at Towson University, (2) HCI at the University of Wisconsin, and (3) Human-Centered Design and Engineering (HCDE) at the University of Washington.

Interviewees drew on their experiences in teaching a total of 31 different courses in which accessibility-related topics were taught. In most of the courses ($n = 26$) accessibility was taught as a 1–2-week module as part of a larger course (commonly in HCI). Five participants also had experience teaching stand-alone courses dedicated to accessibility and/or AT:

(1) "Universal Access Disability Technology in Society," Sri Kurniawan, University of California, Santa Cruz (for details about this course, see Kurniawan et al. 2010).
(2) "Principles and Practices of Assistive Technology," Seth Teller, MIT.
(3) "Assistive Technology and Inclusive Design," Julie Kientz, University of Washington.

(4) "Introduction to Assistive Technology," Amy Hurst, University of Maryland, Baltimore County.
(5) "Design and Human Disability and Aging," Gregg Vanderheiden, University of Wisconsin.

To structure our findings in the next section, we present five themes. The first three were informed by authentic learning theory and concepts from 21st Century Skills framework: (1) prominence of real-world learning environments and making the topics personally meaningful for students; (2) providing opportunities for students to work on collaborative teams to create and share knowledge; and (3) exposing students to accessibility topics in multiple ways. Additionally, we will discuss other themes that emerged from the data: (4) instructor frustrations, challenges, and cautionary tales and (5) the importance of instructor initiative.

In each section, we use emblematic quotes from participants; the quotes were taken directly from the interviews and in some cases were slightly edited for grammar and understanding. Interviewees were given the chance to review and corroborate their quotes prior to publication.

3.1. Real-World Learning Environments and Making Topics Personally Meaningful

There were three common approaches discussed in the interviews and evident in the content analysis that focused on real-world learning and making topics personally meaningful for students: (1) emphasis and awareness of user diversity, (2) simulating disabilities, and (3) direct interaction with end users who had disabilities.

3.1.1. Emphasis and Awareness of User Diversity. When asked about the most important student takeaway, the most common response, expressed by 12 interviewees, was the desire to have students embrace the user diversity they will need to consider in their careers. For example, Sri Kurniawan told us:

> *The one thing that I wanted [students] to take away is to really understand that number one, they are not designing for themselves, they are designing for people with a wide range of abilities and needs and preferences.*

Gregg Vanderheiden elaborated on the theme of embracing diversity by including two additional points: (1) that accessibility is a function of design, using the what-if scenario of human flight:

> *. . .whether somebody can use something or not is less a function of them, than it is the design. Most of us in this class don't consider ourselves to have disability. . .however, if we were exactly like we are, but everybody else had wings, then suddenly we would all have a disability. . . Not because we're any less able, but because the world would be designed differently.*

And (2) an understanding that with age comes disabilities:

> *. . .we will all acquire disabilities—unless we die first. . . . Functional limitations as a function of age is important for people to realize.*

Course materials also emphasized awareness of user diversity, touching on moral aspects, regulatory requirements, and the reality of an aging population. The practical aspects of etiquette for interacting with people with disabilities were frequently addressed, particularly in the lecture slides. Many assignments included a project component that required students to interact and collaborate with a person with disabilities.

Many of the course materials also focused on ways to increase and sustain awareness of accessibility. For example, several class lecture materials included pictures of inaccessible public spaces, with discussion questions that were meant to evoke a visceral response from students.

3.1.2. Simulating Disabilities. Five interviewees discussed simulating disabilities to help students better understand users with disabilities. Steven Reiss reported a common example of this type of activity when he suggested using a tool that simulates color blindness. Other ideas included having students use screen readers and wheelchairs. But the most extensive model of simulating disabilities came from Gregg Vanderheiden in his description of the experience laboratory that he has built at the University of Wisconsin:

> *. . .we have a series of approximately 30 experience stations (15 pairs of stations) that everybody in the class has to complete. At each of the station-pairs we give the student a different limitation (they wear a blindfold, or must use only a headstick, or use special limiting gloves to simulate arthritis, or vision limiting goggles) and two different products. One product is designed poorly (and it is very hard or impossible to use) and one that has been designed well (and it is no problem to use). It is amazingly clear to them how much difference simple design differences can make to accessibility.*

3.1.3. Direct Interaction. By far, the most common approach to making accessibility topics personally meaningful while incorporating real-world learning, mentioned by seven interviewees, was to provide opportunities for students to interact with people who have disabilities. Clayton Lewis summarized the impetus for this activity:

> *The key advice I would offer. . . I believe it's really critical for people to get some first-hand exposure, [some] interaction with people with disabilities. I think it is a subject that is difficult to appreciate from a sort of a book-learning point of view. And not just it can be hard to understand, it's easy to misunderstand.*

Specific examples of direct interaction occurred in two contexts: students in the university and in the general community. In an example of the first context, Clayton Lewis discussed the advantages of having a student with disabilities in the classroom:

> *If you're fortunate enough to have [a student] with disabilities in your class, that can be really great. . .last year I had a freshman student who is blind in one of my other classes. . .When [the student] would present what he was doing, and generally, when he was presenting in the class, I just felt that the people in the class were learning an enormous amount from that because they could see [the student] doing the same things they were doing and being successful doing them.*

Two of the five syllabi included guest lectures from people in the community. Additionally, four interviewees discussed how they involved people in the community. For example, Seth Teller from MIT had his students work directly with someone in the community who had a disability in his course on assistive technology:

> *Well the class is. . . not about developing technology for blind people or people with paralysis. . . It's about connecting with a specific individual and developing an assistive technology for that person. In the projects' components, the students form small teams and each team connects with one person living near campus or working on campus who has a disability. . .The students get a chance to have a real engineering experience with a real customer, if you will, a real live person who gives them very honest reactions about whether what they are doing is useful or not.*

Teller's assigned project also described an opportunity for students to work on collaborative teams, a key element of 21st Century Skills, which we expand in the next section.

3.2. Providing Opportunities for Students to Work on Collaborative Teams

The most common type of assignment discussed in the interviews and evident in syllabi was a collaborative group project that fell into one of two categories: (1) build something and (2) create videos.

3.2.1. Build Something. In the "build something" category, discussed by six interviewees, projects included websites and other ATs; for example, Krzysztof Gajos told us:

> *In my class the artifacts that students are producing are mobile web apps. In particular I emphasize the different ways in which mobile users are impaired and in their final project I encouraged [students] to reason about both permanent impairment and situational impairment that clients of the product would be likely to experience.*

Dan Cosley created a unique team assignment that involved redesigning the game "Concentration":

> *. . .the game where you have a bunch of cards and there's pairs of images on the cards and you flip two over and if they have the same image you score points. The exercise is to imagine someone with some kind of different cognitive ability. Could be young kids, could be someone with weaker perception skills, redesign an interface for "Concentration" that lets people with this impairment still play the game and have fun, and so things like helping people remember things they've touched or spaces they've been around or simplifying the layout or letting them move items to support their own memory.*

3.2.2. Create Videos. Both Richard Ladner and Sri Kurniawan have had their student groups create videos of their project work. Kurniawan discussed videos in the context of an elective course that she teaches. The course is not aimed specifically at students in technology majors and not focused on designing or building ICTs, instead it focuses on students helping people learn technologies:

> *. . .the course project consists of students forming a group of 3 to 4 and then they need to recruit three persons with disabilities or the aging population, and then they need to observe or interview how they go about in their everyday life and paying particular attention to how technology helps them and then after that they need to ask them what sort of technology they always wanted to use but they cannot use because of their condition or situation. And then for the course, the students work with these three persons that they recruited—we call them "partners"—and kind of learn this technology that they always wanted to learn and until the end of the course, the students have to kind of demonstrate through just movies, or audio, or snapshots, that the person was able to do the tasks that they wanted to do with that piece of technology by the end of the course.*

3.3. Exposing Students to Accessibility Topics in Multiple Ways

While direct interaction with people who have disabilities and simulating disabilities were both common approaches to teaching accessibility, several other methods were discussed in interviews and/or identified in the syllabi: (1) evaluating a product or website for accessibility, (2) integrating research and case studies, (3) reflective papers, (4) use of online resources, (5) field trips, and (6) videos/movies.

3.3.1. Evaluating a Product or Website for Accessibility. Four (out of 14) of the course lecture slides included instructions on how to review and improve websites for accessibility. Instructors typically organized their slides by types of impairments (i.e., complete blindness, low vision, color blind, deaf/hard of hearing, physical, and cognitive) and included the needed accessibility requirements to address each group. Instruction either strictly or loosely followed the W3C "easy checks first" guidelines, using the POUR (Perceive, Operate, Understanding, Robust) framework [W3C]. Specific examples included graphic design fundamentals, alt text for images, why and how to avoid repetitive links, how to define row and column headers, and suggestions for creating accessible forms. Several automatic checking tools (e.g., WAVE, TAW, FireEyes) were also presented in the slides. In her syllabi, Heidi Feng included an assignment in which students had to analyze both a website's general usability and its accessibility for people with disabilities.

In a combination of both building something (previous section) and evaluating something, Julie Kientz's students were given three options to work in collaborative teams for their quarter project in her stand-alone course on accessible computing (from her syllabi):

Formative Research: This type of project will focus on understanding the needs of a specific population and how it can be used to inform the design of or refinement of assistive technologies. This could include interviews and/or focus groups with the target population, observations of behaviors, or participatory design sessions.

Prototype: Design, prototype, and evaluate a new assistive technology for a special population. The evaluation for this type of project can be more exploratory, rather than a full scale evaluation, but you must still work with target populations to understand their needs and reactions to prototypes.

Usability Evaluation: Usability evaluation of an existing assistive technology with the specific population. This may include working on an experimental lab setup or fully assessing the usability and usefulness of a specific product through a real-world evaluation study.

3.3.2. Integrating Research and Case Study Readings. Five interviewees suggested that it was valuable to include readings from academic research. For example, Dan Cosley of Cornell University discussed how he incorporated "*papers to talk about some of the research takes on accessibility*." (See the Appendix for some specific readings mentioned by interviewees).

3.3.3. Reflective/Summary Papers. Related to the integration of research readings, it was common to include reflection/summary papers for the assigned readings. In an inventive approach, Amy Hurst had students write weekly blog posts to reflect on the readings and also had students use their blogs to post interesting photos or articles related to the class, along with at least 100 words about the example. We felt this was a creative way to have students help cull the resources available, which some interviewees found overwhelming.

3.3.3. Use of Online Resources. In addition to research papers, additional online resources mentioned in the interviews or listed in syllabi included:

—WebAIM: Web Accessibility in Mind
—W3C's Web Accessibility Initiative (WAI) and Web Content Accessibility Guidelines (WCAG)
—Pilgram [2002], "Dive into Accessibility"
—Horton [2006], "Access by Design: A Guide to Universal Usability for Web Designers"

—United Spinal Association Disability Etiquette Guide
—Henry [2007], "Just Ask: Integrating Accessibility Throughout Design"

3.3.4. Field Trips. Four interviewees included field trips to AT laboratories in their courses; for example, Derek Hansen takes advantage of the accessibility laboratory at Brigham Young's library:

> *. . . any student that has accessibility issues. . . can go to this accessibility lab in the library; they have specialized software there, so they'll have the screen readers and other types of technology that are useful for people with certain types of disabilities . . .students that help run that all deal with accessibility issues themselves, so they give kinda "here's what it means. . ."*

3.3.5. Using Videos and Movies. Three interviewees suggested incorporating movies and videos in the classroom. Sri Kurniawan uses several movies:

> *. . .one of the examples that I can immediately pop up to my head is that when we talk about stroke there is a Ted Talk movie . . .by Jill Bolte Taylor. . . she's a neuroscientist herself and one day she got a stroke and she was talking about the experience of getting stroke.*

Additionally, movies were included in two of the five syllabi, and one lecture. Video topics included assistive learning devices, aging, and the use of screen readers.

3.4. Frustrations, Challenges, and Cautionary Tales

We organized common frustrations, challenges, and cautionary tales into five subcategories: (1) lack of student and/or administrative awareness of the importance of accessibility, (2) difficulty in recruiting participants for class projects, (3) lack of an appropriate textbook, (4) difficulty in engaging students, and (5) avoiding the idea that accessibility is for charitable reasons.

3.4.1. Lack of Awareness of Accessibility Importance. Three of our interviewees discussed frustrations surrounding the lack of awareness about the importance of accessibility-related topics; this resulted in an enthusiasm gap from both students and administration. In the context of student enthusiasm, Richard Ladner offered:

> *I don't know if I'd want to have a (dedicated) course about accessibility, I don't know if very many students would take it. . .I think it's better to have something about it in courses where it's relevant.*

Seth Teller explained that at MIT accessibility did not reach very many students:

> *. . .the class only reaches twenty to thirty students a term, and our department has more than a thousand students, so I'd say the exposure by our department to students broadly is pretty limited. I'd say most of the thousand students at any given year in the program will go through the year without hearing or thinking about accessibility.*

In a related frustration, five interviewees felt that there was not enough administrative support for teaching accessibility due to a lack of awareness. For example, one interviewee told us:

> *We have a department where there are about 120 faculty and one or two (instructors) incorporate this into our teaching. I'm not sure there's much awareness or buy-in of the importance of this field in the administration. I bet that's true in a lot of departments.*

3.4.2. Recruitment. Five interviewees discussed the difficulty of recruiting people with disabilities for class projects. For example, one e-mail interviewee wrote, "often times trying to get enough participants (which is a requirement for the project) from a diverse group (e.g., low vision) is very challenging for students and the university is very limited in helping students or faculty." Suggestions for helping with recruitment involved precourse planning by the instructor; for example, Seth Teller submitted:

> *I have a lot of ties to various agencies and entities that serve people with disabilities . . .and I spend July basically just making a lot of phone calls and talking to people with disabilities and caregivers, clinicians, practitioner. I'll get a list together . . . I put together a capsule description of each person, a paragraph or two about their situation, what their disability is, how it manifests itself as a functional deficit in their lives, what they want to do more independently, and put that in front of the students in a de-identified way. The students go through a matching process where they rank themselves as excited, neutral, or not interested in working with each person based on the capsule description, and on their matched skills.*

3.4.3. Lack of Appropriate Textbook. When we asked about readings that instructors assigned to cover accessibility, four interviewees told us that there were no textbooks that covered the topic well. For example, Sri Kurniawan said

> *We do not use a textbook and the reason is that we were looking at various textbooks and we don't feel that any one text is appropriate for the course because every week we talk about a different disability. . .*

The two textbooks that were mentioned in the interviews and/or listed on syllabi were (1) Cook and Polgar [2007], "Assistive Technologies Principles and Practice"; and (2) Moulton et al. [2002], "Accessible Technology in Today's Business." Other text readings mentioned in the interviews or listed in syllabi included Lazar et al.'s "Research Methods for Human Computer Interaction" textbook, which incorporates many studies on accessibility throughout and has one chapter (Chapter 15) solely focused on including people with disabilities.

3.4.4. Engaging Students. When we asked interviewees about activities they had tried that had been unsuccessful, they commonly mentioned how difficult it was to engage students when discussing legal and technical topics related to accessibility. For example, Krzysztof Gajos told us:

> *I've found that if I teach students the rules and the laws for accessibility that they fall asleep and still do a terrible job on their project, so I have shifted towards trying to build empathy.*

3.4.5. Accessibility is not for Charity. Clayton Lewis discussed the need to emphasize that accessibility is not about charity; he discussed this as a cautionary tale when doing simulation activities:

> *So, for example. . . we know there are things in literature about trying to do something blindfolded, which is a laudable thing to do, but it has to be accompanied by really conveying clearly that this does not in any way replicate what it is like for somebody who's blind.*

3.5. Importance of Instructor Initiative

A recurring theme in the interviews, that supports a major takeaway from Bohman's work, is the importance of an individual's initiative in relationship to accessibility. Because the topic of accessibility is rarely embedded in programs and courses, individual

instructors usually are the ones to take initiative. Most (13 of 18) interviewees had research projects or agendas related to accessibility. For example, Katherine Diebel told us:

> *When I was teaching, I was generally introducing accessibility topics because I'm interested in them and I view them as important . . . For example, one of the classes I taught was the CSC 100. . . The accessibility in the book and the previous offerings of the class included one slide about "you should probably include an alt tag, you know, in your image tag." Which, I'm going, "Eh, I kinda wanna talk a bit more about this.*

Clayton Lewis brought up what we felt was an interesting tension related to this theme: that people who teach accessibility **should** also be those who have direct experience:

> *I think it's the knowledge and not the book knowledge, but the people knowledge. So somebody who looks at disability as a framework of abstraction, I don't think can communicate about it effectively. And it's not just a matter of people not getting stuff, it's a matter of they're getting the wrong stuff. . .wrong attitude. And it's easy to communicate those attitudes and I think the protection against that is people that have the personal knowledge, somebody in a disabilities service organization almost certainly will have that because they are working with students all the time that have disabilities, they see what they can do, they see what they are accomplishing and all of that, and so they have a grounded perspective on what it means and what it doesn't mean and that's really good to convey. If somebody's coming from outside with an outside perspective and tries to teach about it, I'd worry whether they could do it effectively.*

4. DISCUSSION

To summarize the findings, in the context of authentic learning and teaching 21st Century Skills, it is important for students to develop awareness and understanding of the diversity of ICT users through multiple unique experiences. Instructors are currently developing meaningful learning experiences through various activities including research projects that directly involve users with disabilities, guest speakers, field trips, simulating disabilities, and using videos/movies. Additionally, instructors are using multiple resources (e.g., research papers, online resources), in part to offset the perceived lack of a comprehensive textbook.[1] Another common perceived challenge is lack of interest from students and administration, which may lead to low enrollment in courses or programs, which diminishes their sustainability; diminished sustainability is also evidenced in the literature review (see Bohman). Many interviewees emphasized the importance of individual instructor initiative in response to this challenge.

The goal of this research was to better understand how accessibility was taught to support instructors who are interested in incorporating accessibility into their teaching. Toward that goal, we have included two sample syllabi (one each for a 1–2-week module, and a stand-alone 11–15-week term) that we synthesized from the interviews and other course materials (see the Appendix). The synthesized syllabi also serve as a summary of the top-level recommendations from our findings. We hope that the sample syllabi and the corresponding findings can serve as valuable resources for instructors with limited background in accessibility to help them incorporate this topic into their curricula. For instructors who are already teaching accessibility-related topics, we hope that our

[1]During paper revisions, Lazar et al. [2015] was published. It is described as a "one stop guide to understanding accessibility." We have also found that for graduate courses Stephanidis [2009] works well.

findings will provide useful information and be a helpful supplement to their current materials.

However, the results of this research also raised bigger questions and points for discussion. For example, one of the current major challenges for teaching accessibility is highlighted by Lewis' last comment in the findings. If only instructors who have experience with accessible computing are capable or motivated to teach the topic, what does this mean for the ability to build and sustain courses and programs? If there is only a small group of people teaching these topics, what are the missed opportunities for students and therefore the impacts to development of better systems for people with disabilities? This recalls the challenge of student/administration lack of interest, but also prompts the question of how we raise awareness among computing instructors who are *not* involved in accessibility research. Ideas we have discussed among ourselves include directly appealing to our peer instructors and offering ourselves as guest speakers in their courses on the importance of accessibility. However, those solutions may have a small impact and are not scalable. To adequately address challenges in teaching accessibility that can have a larger impact, solutions require long-term collaborative effort on the part of institutions and ICT instructors.

In the following sections, we present three lingering questions from this work that call for discussion and action to more adequately address long-term solutions: (1) approaches to incorporate accessible topics; (2) sharing course resources; and (3) concerns about assessment, that is, sharing ideas about incorporating "authentic assessment," and how to assess the efficacy of varied approaches to teaching accessibility. We conclude with limitations of this work and a call for future research.

4.1. Approaches to Incorporate Accessible Topics

Due to the range of programs, courses, and disciplines that have an interest or overlap in the design of technologies, incorporating the topic of accessibility into the CS curriculum is a complicated task. When incorporating accessibility into a larger program, currently the prevalent practices are either a dedicated course or a module in another course. We have provided synthesized syllabi in the Appendix that addresses two options. Both options have benefits and drawbacks.

The benefit of a dedicated course is that accessibility can be explored in depth, allowing the opportunity to explore multiple disabilities. In dedicated courses, students can build an assistive technology or conduct research with individuals who have disabilities to solve a problem. However, these courses tend to be electives and therefore only attract students who already see the value of accessibility and want to explore it in more depth. As such, several participants in our study mentioned that dedicated courses are under-enrolled and programs dedicated to creating accessibility experts have ceased to exist. The other option, an accessibility module, creates an opportunity for instructors to incorporate accessibility into existing classes. The benefits of this approach are that the content can be embedded and built into topics when and where it makes sense. Additionally, this option can provide opportunities for more students to come into contact with accessibility. However, the drawbacks are that students may only get a superficial understanding of accessibility.

From a programmatic perspective, neither solution may be a fix. When we rely on instructors' and students' personal motivations, we are not addressing the structural problems. If accessibility is optional or an elective, it continues to send the message that it is not a priority for our future designers, developers, and engineers. Teaching accessibility might be the right thing to do, but without a clear mandate the status quo may not change. Thinking back to the legal requirements of accessibility in general, we could wonder if the state of accessibility for physical infrastructure would have changed without legislation such as the ADA that required the change to happen.

Things did not change because a handful of experts decided that they should change; rather, the law requires organizations to account for accessibility. Relatedly, when our programs and universities are ready to commit to accessibility, this commitment would be signaled by requiring accessibility courses and modules rather than making them optional. Therefore, as a community interested in the teaching of accessibility, how can we make these changes at the institutional level?

4.2. Sharing and Developing Accessibility Resources

As stated in the Introduction, there is a recognized need to include principles of accessibility in computing education among academics, industry leaders, and lawmakers. Articles like this, and those in the related literature, are attempting to address information gaps about how to teach accessibility. However, there continues to be a large gap between the needs of instructors and publicly available resources to teach about accessibility. This gap continues to expand due to ever changing technologies. How can information and resources about teaching accessibility be updated and widely shared? How can researchers, instructors, and assistive technology builders and experts collaborate to make high-quality resources to share?

One example of a shared resource that we discussed among ourselves was a collection of freely available media to help people teach accessibility topics; the "Our Story" videos highlighting interviews from many of America's Disability Activists are an effort in this direction [It's Our Story 2010]. In addition, we feel that more first-person examples in the vein of Carmichael et al. [2007], "Rolling" [Berland 2007], and/or "When Billy Broke His Head" [Golfus 1995] would be highly beneficial to provide students with opportunities to understand and appreciate the experience of diverse users in a palatable media form (i.e., video). For a specific example, a set of edited videos that shadow people who have a disability throughout their daily routines that demonstrate challenges could be used as a means to begin discussions with diverse students. How can we create and share resources like this moving forward? Related, how can we keep shared resources up to date?

4.3. Assessment

In the context of authentic learning, examples in the literature review and our findings focused on three aspects: (1) means to cultivate personal meaning for students, (2) relationships to the real world outside school, and (3) opportunities for students to consider and experience the topic(s) in multiple ways. And in the context of the ICT literacy aspect of 21st Century Skills, there were many robust examples of communicating and collaborating with people from diverse groups and in terms of doing ICT-related research. However, beyond student presentations and some examples of peer critiques, there was not a lot of discussion about authentic learning assessment; that is, assessment exercises in which students are learning as they perform assessment task(s). How can we include more authentic assessment in teaching accessibility?

In another kind of assessment, that is, that of teaching, two projects in the literature review, Ludi [2007] and Poor et al. [2012], used empirical measures to try to quantify the effectiveness of their teaching. We feel that more projects like these would be very helpful to discuss the impact of varied approaches using empirical data. How can we assess effective methods for teaching accessibility?

4.4. Limitations to Address in Future Research

While this study provided valuable findings related to teaching accessibility, there were several limitations that highlight more areas for future study. While the purpose of this article was to explore ways in which accessibility is currently taught by a greater number of people than discussed in previous related work, even with the larger

number of participants, our sample size was still fairly small; also, it was limited to only universities in the United States.

In addition, the ways that accessibility-related topics are taught may vary depending on the discipline and on students' existing knowledge. For example, design, engineering, and general education courses may need different course content to meet the learning objectives for each audience. (This point recalls Martin-Escalona et al. who reported that it was challenging to teach accessibility just to a range of engineering students). Further, teaching accessibility might require different strategies and approaches in comparison to teaching other topics within a program; for example, outreach to external stakeholders with disabilities. While these areas were outside the scope of this project, they make for promising areas of research for future work to broaden the discussion of best practices in teaching accessibility.

We also recognize that many ICT practitioners will learn about accessibility through postgraduate training programs, such as WebAIM, which offers training programs several times a year. In future work, we also hope to include instructors from professional training programs and other (non-US) universities.

Moving forward we hope to continue discussion on the points highlighted in this article and find additional means to continue to research and disseminate knowledge about the pedagogy of accessibility. There is a clear need to address the challenges and questions regarding teaching accessibility with long-term solutions. It will take both a continued dedication of individuals teaching these topics and also structural changes to courses and programs. We argue this is important because students with knowledge of accessibility are uniquely positioned to provide compelling user experiences for an often underserved and growing population.

A. APPENDICES—SYNTHESIZED SYLLABI

This section includes two sample syllabi synthesized from the analysis of the course materials and the results of the interviews. The syllabi also serve as a summary of the top-level recommendations from our findings. The first sample syllabus is for an accessibility module to include in another course (1–2 weeks). The second is for a full term stand-alone course on accessibility (11–15 weeks).

A.1. Sample Synthesized Module in a Web-Based Computing and/or HCI Course (1–2 Weeks)

In this module, students will learn to analyze and code web pages for current standards of accessibility. Students will examine how a public web site meets accessibility standards and make recommendations for improvements. Students will use the POUR format to report their findings and recommendations.

Week	Topics	Sample Readings
1	Introduction to assistive technology, universal access, design for all, and ability-based design —Introduce a wide range of disabilities and prevalence —Medical model vs. the Social Model	Wobbrock et al. [2011] Raising the Floor [2011]
2	Web accessibility —W3C Web Initiative —Automated tools —POUR guidelines	W3C Web Initiative, WCAG standards

A.2. Sample Synthesized Syllabi for 11–15-Week Stand-Alone Course

Course Description. In this course, students focus on the design of technologies for diverse end users including elderly and those with physical, sensory, and/or cognitive

disabilities. Students will interact with the material through reading relevant literature, participating in group discussion, and listening to guest speakers. Working alone and in collaborative teams students will (a) examine how technology currently addresses the needs of diverse users; and (b) consider new technologies or modifications to existing technologies that might better address these users' needs.

Course Objectives. After participating in this course, students will be able to

—demonstrate an understanding of the challenges faced by people with disabilities;
—communicate concepts surrounding inclusive design; for example, ATs, universal design and usability, and ability-based design;
—analyze web pages for current standards of accessibility;
—demonstrate understanding of laws and regulations related to accessible design; and
—demonstrate a high level of skill when interacting with individuals from diverse populations

Suggested Assignments.

—Reading summaries: blog posts and/or presentations.
—Examination of how a public web site meets accessibility standards and make recommendations for improvements; use the POUR format to report their findings and recommendations.
—Quarter project: students work in collaborative teams and directly with people who have a physical or sensory impairment to either (1) usability test an existing product/website or AT for recommendations for improvement; (2) perform exploratory user research (interviews, observations) with their target population to ideate a potential new ICT:
  —Proposal with annotated bibliography and schedule
  —Research Protocol Draft
  —Report in CHI extended abstract format
  —Critique of peer student project and paper

Schedule, Topics and Readings. Interviewees did not provide suggested readings for every topic. When applicable, we have added suggestions from Stephanidis [2009]—a text that we have used in a graduate stand-alone course (indicated by *) and recommendations from our experiences teaching these subjects in the classroom (indicated by **).

Week: Sem.	Week: Qtr.	Suggested Topics	Sample Readings
1	1	Introduction to assistive technology, universal access, design for all, ability-based design: —Introduce a wide range of disabilities and prevalence —Medical Model vs. the Social Model —Etiquette	Wobbrock et al. [2011] Raising the Floor [2011] Abascal and Nicolle [2005] United Spinal Association Disability Etiquette Guide [2011] Henry [2007]
2–3	2	Policies, laws, history, and organizations Web accessibility: —W3C Web Initiative —Automated evaluation tools —POUR guidelines	W3C Web Initiative, WCAG standards Pilgram [2002] Horton [2006]
4–5	3	Focus on vision impairments: —Types/causes/challenges and related AT —Guest speaker(s) (e.g., user(s) who is blind and/or researcher in this area)	Bigham et al. [2010] Shinohara and Tenenberg [2007] Gajos et al. [2008]

Week: Sem.	Week: Qtr.	Suggested Topics	Sample Readings
6	4	Focus on hearing impairments: —Types/causes/challenges and related AT —Guest speaker(s) (e.g., user(s) who is deaf and/or researcher in this area)	Huenerfauth and Hanson [2009]*
7	5	Student presentations of web access report	
8	6	Focus on physical impairments: —Types/causes/challenges and related AT —Guest speaker(s) (e.g., user(s) who have physical impairments and/or researcher in this area)	Keates [2009]*
9	7	Focus on cognitive impairments and learning disabilities: —Types/causes/challenges and related AT —Guest speaker (e.g., someone recovered from a brain injury and/or researcher in this area)	Gregor et al. [2003] Lewis [2009]*
10	8	Focus on older adults: —Typical and nontypical aging/challenges	Web Accessibility for Older Users: A Literature Review (W3C)** Making Your Website Senior Friendly (National Institutes of Health)**
11–13	9	Focus on games, entertainment, sports, mobile accessibility, robots, rehabilitation, and accessibility in ICT industry	Grammenos et al. [2009]** Ossmann and Miesenberger [2006]**
14	10	Student presentations of quarter projects	
15	11	Finals week	

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