Evaluating Instructor Strategy and Student Learning Through Digital Accessibility Course Enhancements

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ABSTRACT

University students graduating and entering into technology design and development fields are underprepared to support digital accessibility due to a lack of awareness and training. Teach Access is a consortium of 10 industry partners, 5 advocacy groups, and 20 university partners working to address this issue. In an attempt to bridge the gap between what is taught to students and the increasing demand from industry, the initiative described here was aimed at awarding instructor grants to support the development of accessibility modules in tech-related courses. In our study we surveyed student attitudes toward accessibility pre- and post-instruction of these modules, as well as, instructor strategy. We found that across all courses, student confidence in accessibility-related concepts increased. The largest increases were found in student confidence in defining the Americans with Disabilities Act (ADA) and the Web Content Accessibility Guidelines (WCAG). Our work makes the following contributions: 1) A detailed description of how accessibility was integrated into 18 different university and college courses 2) Instructional delivery methods found to be effective by participating instructors 3) Insights for resource materials development.

Author Keywords

Accessibility; Higher Education;

ACM Classification Keywords

•Human-Centered Computing →Accessibility; •Social and professional topics →Computing education;

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INTRODUCTION

Technology is an integral part of participation in culture, education, and the workplace, and should be usable by everyone, regardless of ability. While there has been innovation and progress in a variety of applications, standards, and regulations - accessibility is still not systemic in the development of new and emerging technologies. Knowledge of accessible development is limited to a handful of domain experts, but to reach the goal of making technology accessible to everyone, it needs to become a mainstream skill.

One of the greatest challenges to making accessible technology more ubiquitous is a lack of awareness and understanding of basic accessibility issues, concepts, and best practices. It is not uncommon that a company with thousands of technical positions (i.e. engineers, quality assurance, designers, product managers, etc.) employs only a few accessibility experts. According to a recent survey conducted by the Partnership on Employment and Accessible Technology, "60% [of tech companies] said it was difficult or very difficult for their organization to find job candidates with accessibility skills" [[30]].

In response to the need for technology employees with a user-centered focus and understanding of accessibility best practices, the industry-higher education consortium Teach Access was formed. As part of an initiative to stimulate teaching and learning of digital accessibility best practices, and in line with research demonstrating the effectiveness of teaching accessibility-related modules [[24] , [27] , [30]], the consortium implemented an incentivized program for instructors interested in teaching accessibility.

To address the lack of education around accessibility and to better understand issues in its design, we have addressed the following research questions:

- **R1.** What learning objectives, instructional methods and resources do instructors use?
- **R2.** What do instructors think supports learning?

- **R3.** What resource materials and delivery methods support student learning?
- **R4.** What learning objectives around accessibility influence outcomes?

In this paper, we describe related works teaching accessibility in computer science courses and surveying other university curricula. We provide an overview of the history and design of the Teach Access organization and programs, introduce the recipients of the 2018 Teach Access Curriculum Development Awards and the courses they taught. We then describe our methods to assess the impact of this program through student surveys administered before (and after) instruction in accessibility, and instructor surveys that were administered after the course. We present results from Likert-scale and open-ended feedback from students and instructors on their experience teaching accessibility course enhancements and reflect on lessons learned and recommendations for future efforts to teach accessibility.

RELATED WORK

A growing awareness of the importance of creating accessible technology for people with disabilities has led to efforts to educate the next generation of software developers in accessibility. A number of initiatives have been aimed at introducing accessibility to students, both stressing the importance of and providing the skills necessary to create accessible content. In this section, we provide a brief discussion of the questions of "how, who, why and what" of teaching accessibility.

Trends in Teaching Accessibility

Ko et al. suggest "three basic strategies for including accessibility and disability in courses: change a lecture, add a lecture, and add a new course." [[17]]. In the domain of changing and adding lectures, accessibility has been incorporated into courses about web design [[14] , [35] , [42]], HCI [[18] , [21] , [22] , [26] 26, [31]], design thinking [[36] , [37]], software engineering [[24]], introductory programming [[8]], mobile app development [[10]] and student capstone projects [[4] ,[11]].

In the "add a course" domain, accessibility is also taught in stand-alone courses, including a course in adaptive technology [[23]], assistive technologies and universal design [41], accessible computing [[6]], usability and accessibility [[16]], and accessibility and innovation [[27]]. A general education course on accessibility for non-CS majors has also been created [[18]]. Two MOOCs on accessibility have reached over 10,000 students [[13]].

Some accessibility efforts have gone far beyond adding a single course. At University of Dundee, accessibility topics are incorporated into a number of courses, including programming, data structures and algorithms, and HCI courses, throughout the four-year curriculum [[41]]. The Oslo and Akershus University College of Applied Sciences developed a Master's Program in Universal Design of ICT [[7]]. Bohman provides an in-depth analysis of the integration of accessibility into three university graduate programs in the US in his thesis [[3]].

Who Teaches Accessibility?

In assessing the current state of accessibility education, Putnam et al. conducted interviews with 18 instructors who teach accessibility. The interviews revealed common themes, such as the importance of teaching students to design for diverse audiences. The need to increase student empathy for people with disabilities was stressed, in particular through the use of simulations or interactions with people with disabilities, videos, field trips, or collaborative projects. Challenges reported included a lack of awareness of the importance of accessibility, lack of appropriate textbooks, and the difficulty of engaging students [[33] , [34]].

A more wide-scale survey was conducted on 1,857 faculty members, of which 375 reported teaching about accessibility. An analysis of the survey responses indicated that instructors who teach accessibility are overwhelming likely to be female, experts in HCI, and have family members, friends or acquaintances with disabilities. Similar to the interviews of Putnam et al., the survey also revealed that the most critical barrier to teaching accessibility is the lack of instructor knowledge and resources about accessibility, and the need to have course-specific accessibility resources [[38]].

Assessing Accessibility Education

In educating students about accessibility, common goals are to increase students' awareness of people with disabilities and knowledge of how to make technology more accessible. A number of assessments have focused on measuring how well accessibility interventions have accomplished those goals. For example, an analysis of student attitudes both before and after taking an HCI course that included an accessibility module showed an increase in student ratings of the importance of broadening the range of technology users [[32]].

A series of studies conducted at Rochester Institute of Technology investigated the impact of various accessibility initiatives. In the first, end users with visual impairments served as external stakeholders for student projects. Students' responses to exam questions indicated increased awareness of accessibility, compared to students the previous semester who had not worked with a person with disabilities [[24]]. In the second, students participated in an HCI course that included a week of lectures about accessibility. Differences in scores between pre- and post-instruction indicated increased awareness and (self-reported) knowledge of accessibility following the course [[29]]. In the third, a combined approach was used in which all students in an HCI course received a week's worth of lectures about accessibility; additionally, a subset of the students also worked on projects that included a person with disabilities as an external stakeholder.

The subset of students who had first-hand interactions with a person with disabilities was termed the *Exposure* group; the students who did not were the *No Exposure*. As in the previous study, pre- and post-instruction scores indicated increases in awareness and (self-reported) knowledge of accessibility for all students as a result of the lectures. Students in the Exposure group, however, also demonstrated increased levels of *sympathy* towards people with disabilities, as measured using the IDP scale (e.g. [[12]]). No such increases were evident for the students in the No Exposure group. The authors point out that 1/7 of the student teams in the No Exposure groups (compared to 1/14 of the teams in the Exposure groups) acknowledged that their projects did not accommodate people with disabilities but chose not to address the problem; the authors conclude that accessibility *knowledge* alone "may not be enough to motivate students to address accessibility barriers" [[25]].

Accessibility Learning Outcomes

In the responses to the survey of Shinohara et al., the most common learning objective reported by instructors who teach accessibility was "Understand technology barriers faced by people with disabilities" [[38]]. This dovetails with the discussion of Putnam et al. of the instructional goal of cultivating empathy for those with disabilities [[33]]. However, a survey of 197 developers found gaps in developers' knowledge of accessibility that suggested that there are areas "where developers struggle to empathize with accessibility issues and subsequently design interactions for this demographic," as well as a "lack of understanding in how a person with disability uses technology" which "impacts on how technology interactions are designed" [[9]]. A driving goal, therefore, of research in accessibility education is to find ways to best cultivate an understanding of the challenges and technology interactions of people with disabilities.

One of the themes of the literature on accessibility education is the lack of instructor knowledge and resources. Clearly, many instructors seek guidance on *what* they should do to accomplish that goal. Existing resources for instructors include the *AccessComputing* [[5] , [17]] Knowledge Base [[1]], which includes case studies and practices for instructors.

An attempt to combat lack of instructor knowledge and resources was initiated by Kawas et al., who pioneered "micro" professional development: "a personalized, integrated, and low-commitment approach to teaching accessibility." The authors created mappings from specific CS learning objectives (in topics as diverse as computer vision, algorithms, introductory programming and networks) to accessibility learning objectives, and are working to create teaching materials that reinforce these mappings [[15]].

Finally, an analysis of the educational literature about accessibility found that "the field lacks the pedagogic culture necessary to support widespread excellence in teaching and learning," due to lack of a formal curriculum, an approach to teaching accessibility that is too narrowly focused and insufficiently inclusive to the diverse set of CS students, and a "lack of debate, investigation and evaluation regarding how accessibility is taught and learned," with "insights in this field [that] tend to be based in individual accounts more than detailed pedagogic research" [[20]].

We call for accessibility advocates to build a pedagogic culture by developing resource materials and instructional methods that are evidence-informed. In this paper, we provide evidence that instructional methods and resource materials contribute to student learning outcomes in digital accessibility. Based on these findings, we make design recommendations for materials and instructional methods.

TEACH ACCESS BACKGROUND

In April 2016, the Teach Access kickoff meeting took place at Yahoo! and brought together more than 40 individuals from leading tech companies and universities. The focus of that meeting was to establish goals and tangible projects to develop ways to engage students in fields such as design, computer sciences, and human-computer interaction to be better prepared to enter the workforce and create future technologies that are truly inclusive. On the industry side, this included directors, developers, and project managers of accessibility teams in companies such as Yahoo!, Facebook, Google, Microsoft, Adobe, among others. University attendees included faculty, academic support staff, and other who work with accessibility/disability on their respective campuses. Through two days of discussions and brainstorming it became clear that in order to address the need of industry to be able to hire recent graduates with basic technical accessibility knowledge, a true collaboration would need to emerge between industry and academia.

In order to establish the means to create this sustained collaboration, six distinct task forces emerged out of that initial planning meeting that were each comprised of industry and academic members. Over the past three years, several programs and projects have come out of the work of these task forces. First, the Teach Access Tutorial is a set of best practices for making mobile apps and websites accessible. The Evidence Packet that can be circulated among higher levels of leadership at universities to support the need to infuse accessibility into curricula. Work with organizations like the Accreditation Board for Engineering and Technology (ABET), the Association for Computing Machinery (ACM), and the National Association of Schools of Art and Design (NASAD) to include in their accreditation language an emphasis on the need to understand accessibility basics. And finally, the Teach Access Study Away: Silicon Valley program that brings up to 30 undergraduate students and faculty from a variety of universities to Silicon Valley for an immersive week of study where students learn about the accessibility landscape at several Teach Access technology companies.

Feedback from faculty in the kickoff meeting showed that many wanted to teach the basics of accessibility, but more curricular materials were needed to be able to do this. While industry could provide guidance on the types of skills they look for, they did not have the background in pedagogy and an understanding in how to create university curricula. As such, in 2018 the Teach Access Curriculum Development Awards were established to foster innovative ways of incorporating accessibility into existing courses. Funding was secured from two large private foundation donors to award up to 20 instructors with $5,000 stipends to develop curricular material to teach accessibility, such as modules, presentations, exercises, or curriculum enhancements or changes that introduce the fundamental concepts and skills of accessibility design and development into existing courses. "Instructor" was broadly defined to include full-time, part-time, adjunct, or instructional staff at US-based institutions of higher education as a way to attract a variety of applicants.

The inaugural round of funded proposals spanned the 2018-19 academic year. Twenty-nine instructors applied for twenty available awards. The seven-member Teach Access selection committee assessed each proposal on the following criteria:

- Relevance of the course: How relevant to the goals of Teach Access is the proposed course, based on the provided course title and course info?
- Relevance of the applicant's background/expertise: How relevant is the applicant's background and subject matter to the goal of these grants?
- Likelihood of success based on previous experience: Regardless of how experienced the applicant is with the subject matter, does his/her statement regarding previous experience indicate a likelihood of success?
- Strength of internal promotion plan: Is the applicant's institutional promotion plan likely to expand the knowledge and understanding of accessibility in the applicant's institution?
- Strength of external dissemination plan: How strong is the applicant's external dissemination plan?
- Understanding of the goals of the grant (from written proposal): Does the applicant's written proposal demonstrate an understanding of the goals of the grant?
- Likelihood of expanding knowledge (from written proposal): Does the proposal show a likelihood of expanding students' knowledge of accessibility in a substantive and sustainable manner?

Conditions of the award acceptance included 1) Instructors sharing their course materials that would be posted the Teach Access website, 2) Evidence that instructors presented their new course components to other instructors and administrators at their institution, 3) Administering and sharing results from pre- and post-instruction surveys of students to measure the impact of the curriculum, and 4) Write a summary report about their experiences teaching and developing this content.

Through the Teach Access Curriculum Development Awards, several hundred undergraduates across the United States have been exposed to digital accessibility training in Computing, Art, Psych and Education Departments. In the rest of this paper we investigate the impact of our efforts.

METHODOLOGY TO EVALUATE IMPACT OF 2018-2019 COHORT

This paper reports on an effort to assess accessibility instruction strategies in design, web, computer science, education, and human computer interaction courses during the fall 2018 and spring 2019 semesters. Teach Access surveyed student attitudes toward accessibility before and after accessibility-related course enhancements and granted us this data. We then gathered instructor feedback about their delivery methods, learning objectives, and resources used.

Participants

The first included approximately 400 students enrolled in either undergraduate level (21 courses) or graduate level (9 courses) courses that were taught by the awardees in the second group. Many of these courses were hybrid allowing both graduate and undergraduate students to enroll, and we do not have exact enrollment numbers.

The second group included 12 instructors recruited via email from a mailing list of 19 Curriculum Development Awardees. The 12 instructors are a mix of Computing and Non-Computing (Art, Psychology, and Education) department professors teaching CS or related courses (including one project that funded instructor training) in 16 different colleges from across the United States. A list of the courses included in this work is provided in Table 1. All participation in this study was voluntary; students and instructors were not compensated.

Materials

Surveys were built using Google Forms and distributed via email by instructors to students (pre- and post-instruction), and by the authors via awardee mailing list to instructors (feedback). The students were asked to complete a pre-survey at the beginning of the course or before the accessibility course enhancement was introduced. Students were also asked to complete a post-instruction survey at the end of the course or after the accessibility component was presented. Instructors were asked to fill out a survey after they completed their course or module on accessibility.

The student pre- and post-surveys developed by Teach Access were almost identical with 18 questions in common. The first five required questions related to the student's educational background, asking the college/course, field of study, major and expected graduation.

Confidence in accessibility-related concepts was assessed using eight Likert-scale questions (from “not at all confident” to “extremely confident”) (Table 2). Confidence is a contributing intrinsic factor in self-efficacy, which Bandura defines as “the belief in one’s capabilities to organize and execute a course of action required to produce given attainments” [[2]]. In education, there is evidence that suggests confidence positively impacts skill acquisition and learning [[28] ,[43]]. Student survey questions measured confidence levels in order to assess levels of awareness of accessibility issues. Future interest in accessibility involvement was gauged by three Likert-scale questions. Two questions asked about familiarity with accessibility technology and features.

The student post-surveys had two additional questions related to incorporating learned material. A required open-response question asked for an example of how the student can apply accessible design in their future career or personal life. An optional question asked for the student to provide their email address if they were interested in staying in touch with Teach Access.

The instructor survey asked for feedback on the delivery methods and resources used. In addition to the course name,

Course ID	**Department Type**	**Students (pre, post)**	**Accessibility Lectures**	**Delivery Method**	**Unique Innovation**
Web 1	Computing	(17, 19)	15	L, ICA, HW, SE	N/A
Web 2	Computing	(33, 33)	1	L, ICA	N/A
Web 3	Computing	(16, 16)	1	L, ICA	N/A
Web 4	Non-Computing (Psych / Ed)	(13, 13)	1	L, ICA	N/A
Web 5	Non-Computing (Psych / Ed)	(15, 13)	1	L, ICA, HW	N/A
CS 1	Computing	(27, 11)	No Data	No Data	N/A
CS 2	Computing	(16, 15)	No Data	No Data	N/A
HCI 1	Computing	(4, 4)	15	L, HW, TP, SE, FT, SL, O	Field trip, Service Learning, having students evaluate their previous design/web development work
HCI 2	Computing	(35, No Data)	2	L, ICA, HW, SE, FT, O	N/A
HCI 3	Computing	(51, 49)	4	L, IA	N/A
Design 1	Non-Computing (Art)	(30, 15)	24	L, ICA, HW, TP	N/A
Design 2	Non-Computing (Art)	(25, 18)	2	L, TP	N/A
Design 3	Non-Computing (Psych / Ed)	(18, 16)	26	L, ICA, HW, TP, FT, SL, O	Service learning/interaction with community members
Design 4	Computing	(17, 18)	1	L, ICA	N/A
Design 5	Non-Computing (Art)	(14, 14)	4	L, ICA, HW, TP	N/A
Design 6	Computing	(116, 47)	7	L, ICA	Students develop personas using W3C profiles of people with disabilities
Education 1	Non-Computing (Psych / Ed)	(15, 14)	21	ICA, SE	Online modules
IT 1	Computing	(40, 31)	3	L, ICA, O	Students develop personas using W3C profiles of people with disabilities and user descriptions from the book 'A Web for Everyone'

Table 1. Overview of courses that participated in the [Sponsor Organization] faculty grant program. (L=lecture, ICA=In-Class Activities, HW=Homework, TP=Team Projects, SE=Simulation Exercises, FT=Field Trips, SL=Service Learning, O=Other).

it asked for the total number of lectures and the number of meetings devoted to accessibility related content. Multiple choice options describing the type of disability/disabilities that were covered included: vision, mobility, motor, aging, cognitive, learning, and neurodiversity. We included questions regarding instructor learning objectives and course delivery format. An open-format question asked which methods the instructor found most effective.

The instructors were further asked to indicate the resources they used and their experiences. The resource list included: the Teach Access Tutorial, WebAIM, WCAG, Do-IT resources, Teach Access awardee resources (a 36-item list of links organized by topic and publisher/institution), and Other. The Teach Access Tutorial provides best practices for making accessible mobile and web apps. It includes 20 slides with code examples and interactive exercises. Awardee resources were comprised of a spreadsheet of links for teaching accessibility that is updated as member instructors contribute materials. This sheet has 36 entries so far, and is categorized by topic area, author, institution, date and contact info. Instructors were asked to report their perception of student interest in the topic of accessibility. Perhaps most importantly, the survey asked for feedback on which resources and delivery methods best supported student learning.

Procedure

The student surveys were a required deliverable for the instructors teaching the courses; instructors had flexibility in how and when they were administered (for example, via email, in-class, link on course website). Students were not required to submit the surveys and were not asked their name or email addresses. The instructor surveys were voluntary, and the names were optional (although the course name was required). Instructors were asked to submit surveys for each course or module taught. The three instructors who are authors on this paper were excluded from the instructor survey.

STUDENT FINDINGS

In total, 504 students completed the pre-instruction survey and 354 students completed both the pre- and post-surveys. One accessibility module with 35 students in pre- was unfinished during analysis. There were 18 courses included in this dataset that include both pre- and post-instruction data. We did not include pre-only responses in student comparisons because our analysis was focused on difference scores between survey items. Courses were categorized by the type of department they are offered in (Computing, Non-Computing Art, and Non-Computing Psych/Education), and by the type of course (Design, Computer Science, Web, HCI, and IT). Medians were calculated for Likert-scale response questions, and means and standard deviations used to understand pre-and post-instruction differences, as well as compare of course types.

Student Accessibility Confidence Scores

We saw a general increase in student confidence between self-reported pre- and post-instruction scores (Table 2). We observed the most confidence gains in defining the purpose of the Americans with Disabilities Act (ADA) and the Web Content Accessibility Guidelines (WCAG), scores started out low, and we observed a median increase of 1 point in the post-instruction survey for each. Across all confidence-related question types, scores centered around the mean with a spread less than 1 point (on a scale of 1-5).

Confidence Scores by Course Type

The largest increases in student confidence related to the ADA and WCAG. For confidence in ADA knowledge, 14 courses saw an increase of over 1 point.

Q	On a scale of 1 to 5, how confident are you that you could do each of the following at this time?	Pre	Post	Delta
1	Give an example of a type of disability	4.4 ± 1.0	4.79 ± 0.6	.39
2	Define, Accessibility as the term relates to technology and media	3.8 ± 1.0	4.48 ± 0.7	.68
3	Give an example of inclusive or universal design	3.2 ± 1.2	4.24 ± 0.9	1.04
4	Give an example of how accessible technology is used by people with disabilities	3.5 ± 1.2	4.42 ± 0.8	.92
5	Give an example of how assistive technology is used by people with disabilities	3.5 ± 1.2	4.38 ± 0.8	.88
6	Give an example of a technological barrier somebody with a disability might face	3.9 ± 1.1	4.57 ± 0.7	.67
7	Define the purpose of the Americans with Disabilities Act	2.5 ± 1.3	3.98 ± 1.0	1.48
8	Explain the Web Content Accessibility Guidelines (WCAG) (or other guidelines for accessible design and development)	2.1 ±1.2	3.64 ± 1.1	1.54

Table 2. Overview of eight Confidence-related Likert-scale questions (Q) students were asked and their mean response scores ± standard deviations from pre-and post-instruction surveys, and the delta between pre and post.

For WCAG, confidence increased by 1 point in 6 classes and over 1.5 points in 9 courses. Students in Design courses experienced confidence increases related to the concepts of inclusive or universal design, accessible technology, assistive technology, WCAG, and the ADA (1.28, 1.23, 1.8 mean increases across each, respectively). CS students began with moderate scores across all confidence-related questions, and experienced gains in confidence around WCAG, and ADA (a mean 1 scale score increase in confidence).

Confidence Scores by Course Subject Type

We observed differences in student confidence scores across department type. Education students had relatively high confidence in each area coming into the module (median=4). Confidence in each area was high except for WCAG (median=2). Similarly, HCI and IT students in the study had relatively high confidence going into the module. Within HCI courses, HCI 1 started out confident across each with marginal gains with the exception of confidence increases for WCAG. And HCI 3 experienced confidence gains around inclusive and universal design, the ADA and WCAG. IT students gained the greatest confidence in inclusive or universal design practices, the ADA, and WCAG (all at least one scale score increase). Web students began with low confidence around accessibility concepts but experienced the largest gains in confidence distributed across all confidence-related questions (pre-survey median=3, and post-survey median=5). Overall, design and web students showed the greatest increases in confidence. The mean difference scores in confidence-related questions by course type are as follows: CS 0.7, Design 1.2, Web 1.1, HCI 0.9, Education 0.6, and IT 0.5.

Confidence Scores By Department

Students enrolled in courses within Computing and Non-Computing departments had increases in confidence around accessibility-related concepts. Students in Non-Computing Art departments had the largest increase (Art 1.7, Computing .8, and Psych/Ed .8).

Student's Accessibility Interest Scores

Student interest in learning more, researching, or pursuing a job in accessibility, had high pre-instruction scores (average. of 3.4) and were maintained with slight increase in the post-survey (average of 3.6). Between and within course types, there was also not much difference in student interest in accessibility (HCI 3 had slightly less interest as a class). Table 3 summarizes the median pre-instruction, and post-instruction scores for each question related to student interest in Accessibility. Before and after instruction in accessibility, students expressed more interest in learning about accessibility than pursuing research or work in an accessibility-related field.

On a scale of 1 to 5, how much interest do you have in each of the following?	Pre	Post
Learning more about designing or developing technologies for and with people with disabilities	4	4
Pursuing a job or career in accessible technology	3	3
Pursuing research in the development of accessible technologies.	3	3

Table 3. Median interest in accessibility-related learning, research and work

Between department types (Computing and Non-Computing), interest in learning more about accessibility did not increase between pre- and post-instruction, but scores started and ended reasonably high (See Table 4).

Department Type	Pre	Post	Delta
Computing	3.4 ±1.2	3.5 ± 1.3	0.1
Non-Computing (Art	3.5 ±1.2	3.8 ± 1.2	0.3
Non-Computing (Psych/ Ed)	3.3 ±1.2	3.5 ± 1.2	0.2

Table 4. Mean ± standard deviation scores for student interest in learning more about accessibility by department.

Qualitative Findings in Student Data

We received 350 responses to the student survey question: "how you will apply what you learned about accessible design and development in your future education, career or personal life?" Open-ended survey responses were analyzed for patterns and repetition. Response themes emerged around awareness and intent to implement accessibility best practices, as well as, awareness of and intent to consider people with a range of abilities.

Several students responded that they intended to use their knowledge of accessibility in their jobs/careers (33 responses) and personal work/portfolios (10 responses) without much more detail. For example, P169 replied: *"I will incorporate this into my personal website and documentation of my projects.*"

There was striking repetition in responses around awareness and consciousness with intent to use best practices. Students specifically referenced design and development best practices and testing tools. 58 responses included references to techniques and tools (alt-text, color contrast, WAVE, VoiceOver). Courses that included many responses related to the implementation and awareness of best practices included Web 1, Web 3, Web 5 as one respondent stated: *"When designing websites, I will be more deliberate and mindful about alt labels, semantic tags, etc., to convey the most accurate information about the structure and content of the page." (P21)*

In response to the question of how students will apply their learnings, 28 responses cited consideration and awareness of people (specific disabilities, barriers to accessibility, etc.). Student responses in courses that center around human processes and experiences like HCI 1, Education 1, and Design 3 course mentioned awareness and consideration of a variety of abilities and users. For example, P290 stated:

"I will be more conscious of the needs of others when working on future projects so that it can be enjoyed by more people."

Responses were balanced between student mentions of both best practices and consideration of people in the following course: Design 2, Web 2, HCI 3, Design 2. Of note is the frequency of vague, confused and unsure responses in both CS courses: CS 1 (7 responses out of 11), and CS 2 (7 responses out of 13 complete responses). P66 stated:

"Not completely sure what it is."

INSTRUCTOR FINDINGS

In total, we received 19 responses from 12 instructors (2 of which are authors and kept separate from comparative analysis) that correspond with 16 of 18 available student datasets. Regarding department type, we received responses from 6 Computing, 2 Psych/Ed, and 3 Art department instructors, as well as one instructor who taught across all three department types (A1) (See Table 5).

Instructor ID	Department	Class IDs
I1	Computing	HCI 1
I2	Computing	Design 6
I3	Non-Computing (Psych/Ed)	Design 3
I4	Computing	Web 1
I5	Non-Computing (Art)	Design 5
I6	Computing	HCI 3
I7	Non-Computing (Art)	Design 1
I8	Non-Computing (Art)	Design 2
I9	Non-Computing (Psych/Ed)	Education 1
I10	Computing	IT1
AI1	Computing, Non-Computing (Art), Non-Computing (Psych/Ed)	Design 4, Web 2, Web 3, Web 4, Web 5,
AI2	Computing	HCI 2

Table 5. Overview of courses that participated in the Teach Access program. (I - Instructor, AI-Author Instructor)

Instructor respondents reported teaching an average of 8 lectures/class meetings that included accessibility-related content, and that number of class meetings ranged between 1 and 25 lectures/class meetings. In response to the question "What disabilities did you focus on in your course enhancement?", instructor instructors reported that they focused on vision-related disabilities (16), with motor and hearing at a similar frequency (14 and 13 responses, respectively). 10 Instructors reported focusing on disabilities related to mobility, 10 cognitive, 5 aging-related, 3 learning and 2 neurodiversity.

DISCUSSION

R1. What learning objectives, instructional methods and resources do instructors use?

Instructor Learning Objectives

Instructors were surveyed about the learning objectives that they used to guide the development of their accessibility enhancements/modules. The most common learning objectives reported by instructors were for students to understand technology barriers (16 responses) and universal design, ability-based design, inclusive design, and participatory design concepts (14 responses), as well as be able to evaluate web pages by accessibility standards and heuristics (e.g. WCAG) and to develop accessible web technologies (14 responses) (Table 6).

Understand technology barriers faced by people with disabilities	15
Understand design concepts: universal design, ability-based design, inclusive design, participatory design, etc.	14
Engage with individuals from diverse populations appropriately	10
Be able to evaluate web pages by accessibility standards and heuristics (e.g., W3C, WCAG)	12
Be able to develop accessible web technologies (e.g., use of alt-tags, captioning videos, and describing images)	12
Be able to employ design techniques: personas, paper prototyping, high-fidelity prototyping	10
Understand legal accessibility regulations (e.g., Section 508, Americans with Disabilities Act, etc.)	9
Understand the different models of disability (e.g., social, medical or legal models)	6
Be able to develop with accessibility focused technical languages and tools (Apple's UI Accessibility Programming Interface, Android Accessibility Events, Universal Windows Platform)	5
Other	0

Table 6. Instructor's reported learning objectives

Methods of Delivery/Instruction

Instructors reported using a variety of methods to teach accessibility. Most frequently mentioned were lectures (15), in-class activities (14), homework (7), team projects (5), simulation exercises (4), field trips (3), and service learning (2) which is a teaching method in which students learn through participation in service that meets an actual community need or needs [39].

Resources to Support Teaching and Learning

Participant instructors drew from a range of resources. Most commonly, the Teach Access Tutorial (11), Web Content Accessibility Guidelines (WCAG 2.0) (11), WebAIM (7), WCAG 2.1 (5), and DO-IT resources (3). Other open responses included online searches (2), books (2), and instructional design best practices (1).

Several instructor participants reported difficulty in using the resources because of their volume (A1, I9, I3) and technical density (I7, I8, I4).

Regarding resource volume I9 stated:

"*There were a lot of resources, but in some ways there was too many and making sense of it all was challenging*."

With regard to technical density, I7 stated:

"*Most of the materials out there assume a level of technical and conceptual understanding*" and I4 stated that, "*The WCAG guidelines are still very difficult for students to understand and work with. Yes, they provide tools to make it easier, but they still are difficult.*"

Overall, 56% of instructors responded that their course enhancement will be taught again, and 69% responded that since beginning with this work, other members of their department/academic community expressed interest in teaching accessibility best practices.

R2. What do instructors think supports learning?

When asked "What delivery methods did you find most effective at teaching accessibility best practices and why?", instructors reported a variety of responses - many of which related to first-hand experience through simulation exercises (1), field trips (2), videos (1), screen reader demos (4), and service learning (1). Other instructors mentioned in-class activities/discussions (4), and lectures (2). I3's response captures their thoughts about firsthand experiential learning:

"…service learning and direct interaction with community members as part of the design/research process may have been most crucial to changing perceptions" (I3)

R3. What resource materials and delivery methods support student learning?

Based on both student pre- and post-instruction and instructor survey data, it seems that the materials, resource adaptations, and delivery methods used benefitted student learning. There was some frustration on the part of instructors with the number of resources and technical density, but no clear student outcome evidence for commonly used resources (WCAG, WebAIM, Teach Access Tutorial, etc.). With regard to specific delivery methods, Design 3 and HCI 1 course instructors engaged student through both field trips and service learning. Of note, instructors who engaged students through both field trips and service learning (Design 3 and HCI 1) had the most significant increase in confidence scores (Design 3) or had the highest post-confidence scores (4.8-5 out of 5) around confidence question #s 2-5 (HCI 1).

Regarding the number of accessibility lectures included in course enhancements, students in courses with more lectures had on average less confidence post-instruction. The courses that had the highest numbers of accessibility-related content were Design 1 (24), Design 3 (26), Education 1 (21), Web 1 (15), and HCI 1 (15 accessibility lectures). When compared with all other Design courses (1-7 lectures), students in Design 1 and 3, had less confidence post-instruction than design courses with less lectures. Similarly, Web 1 students had an average confidence score of 3.9 compared to Web 3 students that had 1 full lecture and an average confidence score of 4.4.

R4. How do learning objectives around accessibility influence outcomes?

Student confidence ratings in areas that correspond with stated learning objectives showed a marked increase (ADA 35% increase, and WCAG 46% increase in self-reported confidence post-instruction). Inclusive design was a frequent learning objective amongst instructors, and students gained confidence about it (25% increase across all courses). Understanding barriers that people with disabilities face was the most frequently answered learning objective, however students did not report a large boost in confidence pre- versus post-instruction (.6 increase). Students were already quite confident about barriers going into instruction (3.95).

Our main contributions of this work are 1) providing a detailed description of how accessibility was integrated into 18 different university and college courses, and 2) reporting notable increase in confidence scores across all areas of accessibility (with large increases in ADA and WCAG), 3) capturing instructors delivery methods, and 4) providing insights into the development of accessibility materials.

Although lectures and in-class activities were the most predominant instructional delivery methods used, instructors did not always consider them to be the most effective Instead, instructors felt that experiential learning opportunities had the most impact. They reported using activities such as screen reader demos, service learning, field trips, videos, and guest lectures. Although these opportunities were not offered to students in single accessibility lecture course enhancements, a higher number of accessibility-related-lectures did not relate to increased student confidence. Perhaps a limitation of confidence scores in demonstrating actual learning, courses with 1-7 classes had on average higher confidence scores. This observed relationship could indicate that less is more, and students have an opportunity to practice and apply their learnings in the remainder of the course. However, we do not yet have enough evidence to say there is a relationship between the number of lectures and student confidence.

Reflections on Course Materials

There is great opportunity to enhance the resource materials that instructors and students draw on in teaching and learning about accessibility. There are many resources available, but little evidence to support which are optimal.

Although an understanding of the barriers faced by people with disabilities was a common learning objective for instructors, this was something that students already seemed to be aware of. In line with the findings of Ludi et al. [27], our data also show that students are interested in learning more about accessibility. Perhaps rather than barriers, focus should be on developing examples of successful accessible design, and the work that needs to be done to achieve it.

Teach Access and educational institutions have an opportunity to develop materials using the instructional methods that instructors seemed comfortable using. The design of hand-on activities, local community partner contacts for service learning, and use of evidence-based personas may enhance instruction and provide students with opportunities for experiential learning.

Many instructors were unsurprisingly put off by WCAG. This dense technical document is ironically, inaccessible for many beginners interested in learning about accessibility, and requires prior knowledge to navigate effectively. Regarding student learning, even though we saw the most significant confidence gains in defining the purpose of WCAG and the ADA, the post-instruction mean confidence scores for these activities were still noticeably lower than the scores in the other areas. While we were pleased to see the increase in these scores after the course, we think there is more that can be done to enhance confidence and learning of these essential accessibility concepts.

Field-of-study-specific accessibility resource materials could make the search for relevant content in the ADA and WCAG much easier. Instructors also reported using the Teach Access Tutorial (which is primarily web design-oriented), perhaps more hands-on activities like this could be created for different fields of study.

Encouraging Careers in Accessibility

It is important to note, that confidence was gained without diminishing interest accessibility. However, no sizable increases were observed in student's interest in accessibility. The small increases in student interest, may indicate that there is opportunity to represent the need for innovation and available workforce opportunities in accessibility. To inspire interest to study, research and/or work in accessibility, there is an opportunity to create resources and materials that highlight and demonstrate learning opportunities, research needs and methods, and jobs in the field.

LIMITATIONS AND FUTURE WORK

Our course enhancements provide a valuable overview of the impact of this work. However, our ability to deeply describe student learning outcomes is limited by the available Likert-scale confidence and interest scores. In the next cohort, we plan to expand our evaluation instruments to include qualitative data regarding student knowledge, skills, and attitudes.

While we found our instructor data valuable, not all not all faculty involved in this research chose to participate in our survey, so it is an incomplete dataset. To address the issue of bias from instructors who are also authors, we separated our results in learning outcome comparisons and only reported on author delivery methods and learning objectives. As this program grows, we will build a larger community of instructors that can contribute to this research without potentially biasing results.

There may be invisible factors impacting our data (including instructor and cohort differences). In-depth interviews with students and instructors will provide valuable insight into potential invisible factors, and the experiences of teaching and learning accessibility. In future, we are interested in better understanding the impact of graduate and undergraduate accessibility education. Additionally, researchers and organizational advocates of digital accessibility education should explore the development and evaluation of evidence-informed accessibility curricula, including delivery methods and resource materials.

CONCLUSION

In this paper we have summarized our efforts to better understand student learning through digital accessibility course enhancements, and instructor approaches to teaching accessibility. We have provided a detailed description of our findings, along with recommendations for future instructional delivery methods, and resource material development.

As the demand for digital accessibility consideration and best practices in product development increases, so does the demand for accessibility education. It is our hope that this work lays the groundwork for the development of effective teaching tools and in turn, the creation of a more accessibility-aware workforce.

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