Participation at What Cost? Teaching Accessibility Using Participatory Design: An Experience Report

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ABSTRACT

As institutions respond to market demand in their training of the next generation of technology designers, there is an increasing awareness of the need to add accessibility to computer science and informatics curricula. Advocates have suggested three strategies for including accessibility and discussions of disability in courses: changing a lecture, adding a lecture or adding a new course. In this paper we report on our experiences with the latter; incorporating accessibility within two new graduate and undergraduate inclusive design courses taught concurrently. We found that while the use of participatory design was decidedly effective in supporting student learning and ameliorating ableist attitudes, creating and managing teams comprised of students and visually impaired co-designers proved challenging. Despite these challenges, overall, students demonstrated steady growth in their grasp of inclusive design concepts as they tackled accessibility challenges through a series of mobility-related group projects. Efficiencies were also realized through the concurrent teaching of both courses though the pace of course deliverables proved challenging at times for undergraduates. We argue that a review of our experience may help others interested in teaching accessibility related courses, specifically in course design and execution.

CCS CONCEPTS

• **Social and professional topics →Computing education programs; • Human-centered computing →** *Accessibility theory, concepts and paradigms;*

KEYWORDS

Accessibility; assistive technology; education; participatory design

1 INTRODUCTION

Persons with disabilities use a range of assistive technologies to overcome barriers that may impact their daily lives. Visually impaired web users, for instance, may use screen readers or other text to speech technologies to interact with resources on the largely visually-oriented World Wide Web [25, 26]. Persons with auditory disabilities may make use of increasingly advanced captioning technologies to enhance their experience with live presentations or interpersonal dialogues [13, 14, 27]. Beyond these two examples there are many other emerging technologies that aid persons with cognitive, motor, speech or other disabilities with everything from eating more effectively [17] to gaming [29]. While these varied technologies have significant differences, the increasing emergence of novel assistive technologies broadly reflects an industry trend towards a greater understanding of end user diversity. This increasing recognition that end users are not a single homogenous group has spurred a demand for technology designers with a skillset rooted in user-centered design and accessibility [1]. Meeting the increased demands for accessibility-minded technology professionals is challenging, however. A 2018 report from the Partnership on Employment and Accessible Technology, for instance, indicated that while 84% of the companies surveyed believed hiring designers with accessible technology skills was important, 60% said it was difficult or very difficult to find job candidates with the requisite accessibility skillset [1]. Given the important role that colleges and universities have in producing this skilled workforce we argue that the problem of supply may be at least partially attributable to issues of when, where and how accessibility is being taught and who is motivated to teach it. While much is known about how to teach accessibility in a theoretical sense, we argue that much can be learned through the review and discussion of practical experiences teaching accessibility at the university level. A knowledge gap in this regard may exacerbate the inherent challenges of teaching accessibility and may result in accessibility and disability related courses being infrequently taught. Our goal with the present report is to contribute to the literature an exploration of our experience in developing and teaching concurrently two courses on accessibility at a public university. We believe that by sharing our experiences we may assist others interested in teaching accessibility with an example course structure, sample projects and best practices.

2 BACKGROUND AND RELATED WORK

Most prior work has explored the incorporation of accessibility as a part of software engineering instruction, through introductory web development courses, or in Human-Computer Interaction (HCI) or design-focused courses. Martin-Escalanoa, Barcelo-Arroyo and Zola, for instance, describe how a topic on accessibility was introduced across five different engineering degrees as a part of engineering instruction; electrical, electronics and automatic control, industrial product design, electronic systems and computer science [19]. They found that students performed differently within the largely project-based courses depending upon the degree pursued. Students from Product Design, for instance, produced the highest grades while students in CS and Electronic Systems (ES) obtained the lowest. Upon reflection, the authors surmised that learning outcomes may be improved through an approach that involves mixed project groups composed of students pursuing different degrees. Ludi [18] similarly studied the incorporation of accessibility as part of software engineering instruction through research that compared results from a group-based undergraduate requirements engineering course. One group of students within the course was assigned projects with accessibility requirements while the other group delivered projects without accessibility requirements; the course content was otherwise identical for both groups. Ludi observed that the group assigned projects with accessibility requirements acquired new domain knowledge in accessibility throughout the course of the project. By the course's conclusion the "accessibility requirements" group demonstrated an understanding of how to communicate and collaborate with visually impaired stakeholders and gained an awareness that disabled users are not a homogeneous group. These students reflected that persons with often very similar disabilities may have unique needs.

Ko and Ladner have advocated three different strategies for including accessibility in courses: change a lecture to focus on accessibility, add a lecture on an accessibility topic or add an entirely new course [15]. They have described their experience in utilizing the former through the incorporation of accessibility related content into a widely taught undergraduate web development course. They found that through collaboration and brainstorming sessions involving instructors with little prior expertise in accessibility, that they were able to ideate on accessibility related web topics. The developed materials were ultimately piloted by one of three selected instructors. Rosmaita similarly explored the incorporation of accessibility into a web design course [21]. Arguing for an *accessibility-first* approach, Rosmaita proposes that by emphasizing the needs of visually impaired screen readers users, students become better engaged with the course content while learning how to design and develop with accessibility in mind. Students will specifically, he argues, gain a better understanding of the need to separate content from presentation, gain a greater appreciation for extensibility and multi-modality and will grow to understand the relationship of computer science to the social aspects of computing.

Shinohara, Bennett, Wobbrock and Pratt have explored the incorporation of accessibility into design-focused courses [22, 23]. The authors conducted a design course study to investigate how student designers regard disability. They additionally explored how designing for both disabled and non-disabled users encouraged students to think about accessibility [22]. They found that by separating the exploration and consideration of accessibility from mainstream design approaches like User Centered Design (UCD) students adopted the notion that accessibility should be someone else's responsibility. They also found that many students initially held an "ableist" attitude in their initial approach to accessibility that was ameliorated through interaction with persons with disabilities during project-based activities. The authors further explored pedagogical approaches to accessibility by incorporating accessibility content into a design thinking course and making observations of student learning [23]. They found that while students grasped design concepts and were adept at designing for disabled and nondisabled populations independently, they faced challenges in producing more universal designs intended to be used by both disabled and non-disabled users.

3 CASE STUDY: INCLUSIVE DESIGN AND ACCESSIBLE TECHNOLOGY

We present a case study documenting our experience teaching two courses, taught concurrently, on accessibility: HCC 8810, "Inclusive Design and Accessible Technology" and CPSC 1990/3990, "Creative Inquiry: Introduction to Inclusive Design and Accessible Technology". The aim of both courses was to introduce students with a background in computer science, human-computer interaction, human-centered computing or human-factors psychology to accessibility while exploring key concepts through project-based instruction. The courses were taught separately, with distinct lecture times but were otherwise identical (e.g. identical lectures, modules, course content, due dates, instructor, etc.). HCC 8810 was listed as a 3-credit hour graduate Human-Centered Computing course with a final enrollment of six students. CPSC 1990/3990 was listed as a 3-credit hour undergraduate Computer Science course with a final enrollment of five students. The overarching goal of both courses was to aid students in learning how inclusive design practices may be used to identify user characteristics, study user needs, ideate, design, prototype and evaluate technologies for accessibility; specific learning outcomes are described in Table 1.

3.1 Assessments

The majority of coursework was done collaboratively in small teams with the exception of discussions, reflections and the midterm exam. The following breakdown was used for course deliverables: assignments (35%), discussions (5%), mid-term exam (10%), project video (5%), project report (10%), final project prototype (30%), prototype evaluation (5%).

3.2 Lecture Schedule and Course Content

Both courses were taught on Tuesday and Thursday of each week, excluding holidays, within two 75-minute lecture slots. In total, there were 29 available time slots for both courses over the Spring 2019 semester. Classes met 27 times over the semester with two cancellations to account for out-of-class working periods. Course content was delivered within 10 modules, the majority of which contained content for two to three lectures, readings and various related media.

Module one involved an introduction and welcome to the course. Students were given a course overview, reviewed the syllabus, were presented with course expectations and were introduced to the course structure and content locations on the Canvas learning management system.

Table 1: Description of student learning objectives for HCC 8810 and CPSC 1990/3990

Objective	Learning Objective Description
1	Describe the characteristics of various disabilities as they relate to computer and technology use.
2	Describe how people with disabilities and older adults use assistive technologies (e.g. screen readers, keyboard/mouse alternatives, etc.)
3	Describe inclusive design as a methodology and understand how to practically incorporate principles of accessibility into the design process.
4	Describe the philosophical basis and rationale for accessibility.
5	Describe the characteristics of inclusive technologies.
6	Design and implement inclusive and accessible systems.
7	Describe the mechanisms that exist for a technology professional to evaluate a technology for accessibility.

Students also submitted a discussion exercise where they introduced themselves, described their background relative to design and accessibility and articulated what they hoped to get out of the course.

In module two, students were introduced to the concept of inclusive design and related theories and through videos, selected readings and in-class discussions explored the relationship between theories of design and accessibility.

Module two involved the first group design activity where students working in small teams of two to three persons were asked to identify 10 problematic control panels that they encountered in daily life, identify the design breakdowns and select one panel to be redesigned. The final deliverable was a poster outlining the research and design process that was reviewed during an in-class critique.

Module three was the first in a four-module series that explored specific types of disabilities and related assistive technologies. Module three was focused on visual impairment and blindness and involved lectures, videos, and readings which explored the causes of visual impairment, appropriate terminology related to visual impairment and assistive technologies like screen readers and refreshable braille displays [26]. Module four explored mobility disabilities and related assistive technologies. Module five explored auditory disabilities. The series concluded with module six, which explored cognitive disabilities through lectures, videos and selected readings.

Modules seven through ten saw students explore inclusive design while applying what was learned through a two-phase design project with distinct research and design activities.

3.2.1 Phase 1: Accessible Transportation Chains. The approximately 57 million people in the United States with visual, hearing, cognitive and mobility disabilities often face significant barriers to personal mobility and transportation [10]. Recent research, for instance, has indicated that as many as 20% of the disabled in the US face transportation barriers with 45% of this group lacking access to a personal passenger vehicle [24]. This problem may be especially pronounced for persons with visual disabilities. Unlike amputees or persons with partial paralysis, there are no commercially available assistive technologies that enable persons who are blind or those with significant low vision to legally operate conventional motor vehicles.

Emerging transportation technologies hold tremendous potential in addressing the multifaceted transportation problems with which the disabled must contend. The combined use of concierge or ridesharing applications (e.g. Uber, Lyft, etc.), fully autonomous vehicles, light rail, automated shuttles, and conventional buses now provides a conceptualized scheme for enabling the visually impaired to independently travel from a point of origin to a final destination. The combined use of these transportation technologies has been described by the U.S. Department of Transportation's Accessible Transportation Technologies Research Initiative (ATTRI) as the "accessible transportation chain" [12]. But what is the outcome if one or more of the "links" within this transportation chain is inaccessible?

In Phase I of the semester project, students were asked to explore the concept of an accessible transportation chain comprised of emerging technologies through the design of a pre-trip concierge mobile application for an autonomous vehicle. Students were told that the designed application should be accessible for users with visual disabilities and that the system should allow a user to schedule a trip in an autonomous passenger vehicle while remaining situationally aware throughout the process. In small teams of two to three, students were asked to: 1) conduct user research using focus groups and interviews, 2) conduct a literature review or video analysis of the user experience with related technologies (e.g. Uber or Lyft), 3) aggregate their findings and identify user needs through affinity diagramming, 4) construct personas that reflected the main themes uncovered during user research, 5) brainstorm design ideas to address user needs, 6) create scenarios and storyboards, 7) produce a system task flow diagram and 8) create wireframes of the final concierge application.

3.2.2 Phase 2: Autonomous Vehicle Human-Machine Interfaces. In Phase II, students were asked to extend the design context of Phase I by exploring the interaction of a person with a visual disability with an autonomous vehicle human-machine interface (HMI). Students were asked to consider how a visually impaired user, once inside an autonomous vehicle with the assistance of the pre-trip concierge application, would interact with the autonomous vehicle during a trip itself. In Phase II an Institutional Review Board-approved participatory design process was prescribed wherein each student team would be joined by a visually impaired co-designer. Visually impaired co-designers were compensated with a $10 prepaid gift card for each participatory design session. Using personas developed by the course instructor as part of a research project on autonomous vehicles, teams developed a usage scenario, storyboards and low to medium fidelity prototypes within iterative participatory design sessions. As a kick-off activity intended to ease students into the collaborative participatory design process, a site visit was organized to the National Federation of the Blind state office in Columbia, South Carolina and the South Carolina Commission for the Blind. During the trip students observed expert visually impaired screen reader and refreshable braille display users. One of the goals of both visits was to ameliorate the potential for ableist views cited by Shinohara, Bennett and Wobbrock [22] prior to working directly with their visually impaired co-designers.

4 DISCUSSION

In discussing our findings, we draw upon observations, review of contemporaneous instructor notes and a preliminary analysis of student reflections and writings. We believe that a discussion of our experience may prove beneficial for educators teaching courses of this type, and especially so for those considering the use of participatory design.

4.1 Lectures

A variety of methods were used to teach the material covered throughout the modules. Modules three through six, given the focus on specific disabilities, tended to be longer and in some instances contained material drawn from the related medical literature. An attempt was made during these modules to focus on the underlying causes of the specific disability in lecture one, while focusing on assistive technologies, case studies and multimedia examples (e.g. videos of technology usage) in lectures two to three (as applicable). In written reflections using the discussions feature of the Canvas learning management system, and during in-class discussions, students reflected on this approach. Overall, students responded well to the multi-media aspects of the modules but indicated that aspects of the slide-based lecture material were not as engaging. In subsequent semesters, our intent is to address this issue by developing our own videos to supplement publicly available videos. We intend to make this video library available to the larger research community through distribution on publicly available video platforms.

4.2 Participatory Design

The participatory design process of Phase II was a major success of the course. Students were very engaged in the design activity throughout the participatory design process and within project reflections, writings and discussions students indicated that this was one of the more engaging aspects of the course. This process was aided by the South Carolina National Federation of the Blind who assisted in the recruitment of visually impaired co-designers located in close proximity to the university campus. In total, three co-designers were involved in the courses who met three to four times each with their assigned student team (2 graduate teams, 1 undergraduate team). These design teams were successful in conceptualizing three autonomous vehicle assistive technology prototypes, from which low fidelity (e.g. paper and cardboard) prototypes were produced. Using these mockups, students created 2 to 3-minute video enactments called “video sketches” which demonstrated each prototype’s practical use in an autonomous vehicle.

Students also responded favorably to the contrast of design with and without a de facto domain expert co-designer between Phases I and II. In Phase I students were asked to conduct user research and follow a structured design process in the design of a concierge application intended for use with an autonomous vehicle. By first attempting such an activity relying solely upon intuition, lectures and the literature, students expressed a greater appreciation for the domain expertise of their visually impaired co-designers in Phase II of the project. We argue that the combination of site visits to organizations serving disabled persons coupled with the use of participatory design gave students a greater appreciation for the innate abilities of disabled persons while ameliorating “ableist” attitudes. Our findings in this regard largely support those of Shinohara, Bennett and Wobbrock [22].

While successful, the use of participatory design was not without drawbacks. The use of this process entailed financial costs, which were nominal, as well as recruiting and logistical costs, which were significant. While an existing relationship with the leadership of the National Federation of the Blind was leveraged to assist in co-designer recruitment, recruiting participants still proved challenging. Though the initial pool of interested persons was sizeable, identifying participants: 1) within close proximity to the university, 2) who were able to commit to meetings with students over a several week period and who, 3) could attend during hours that varied depending upon student availability, significantly narrowed the pool of those interested. By involving co-designers external to the course, it was also necessary to seek institutional review board approval and closely monitor communication between and interaction with the students and the de-facto study participants.

4.3 Time Slot

An important but overlooked logistical issue had some impact on the graduate course specifically. During the course scheduling process, the graduate course was assigned an 8 am time slot. While class absences were not a major issue during the semester, this early time slot proved problematic from a logistical perspective in that it hindered collaborations between graduate student teams and their visually impaired co-designers. Graduate groups were therefore forced to meet more frequently outside of class hours which proved challenging from a logistical perspective. We recommend a greater consideration of logistics when setting course meeting times.

4.4 Readings

Neither course used a central textbook. Instead, relevant papers were drawn from the scientific literature and assigned to students with the intent of supplementing lecture materials, in-class discussions and assignments. In module two, which focused on the theories of design for disabled users, students were assigned papers on Design for User Empowerment [16], User Sensitive Inclusive Design [20], Universal Design [2] and Ability-Based Design [28]. In modules three through six, as specific disabilities were discussed, relevant papers were assigned that reflected research and researchers focused on the module's disability of interest. While this approach proved acceptable, we argue that for both courses a single textbook would have been preferable. In the undergraduate course especially, students were unaccustomed to consuming information from multiple discrete manuscripts and expressed some difficulty synthesizing and drawing global conclusions from different researchers. For the graduate students, all of whom were accustomed to drawing information from the literature, this discordance was less an issue but based on our observations and student feedback they likewise would have benefitted from a central text.

4.5 Work Load

There was a significant amount of material covered within the course. In addition, the projects and assignments themselves were demanding, with specific activities closely tied to detailed grading rubrics. We expected students to spend between eight and 12 hours per week on the course. Within their project reflections and in-class discussions, students reported that they were spending in some cases considerably more time per week on the course in addition to time spent meeting with their project teams outside of class hours. While the undergraduate students were generally agreeable to the additional workload, this caused frustrations for some of the graduate students. From the midpoint of the semester onwards, assignment due dates were adjusted to allow for more time to complete deliverables and time was set aside for in-class team working periods. Based on our enhanced awareness of workload concerns from this semester, we anticipate providing more time between deliverables and more in-class working periods in subsequent semesters.

4.6 Team Composition

Data was collected early in the semester on student backgrounds to enable the instructor to balance the student teams for technical skills. This was initially motivated by a desire to have students develop working medium fidelity prototypes by the semester's conclusion. A decision was made early in the semester however to allow teams to be self-organizing given the small class size and the realization that producing working prototypes was somewhat overly ambitious given the limited coding skills of some students in both courses. Students in both the graduate and undergraduate courses did a good job of organizing themselves early on and teams remained consistent from the midpoint of the semester onwards. The resulting groups were mixed in terms of the degree being pursued. All graduate groups for instance included a mixture of Human-Centered Computing and Human Factors Psychology doctoral students. Mirroring the observations and suggestions of Martin-Escalanoa, Barcelo-Arroyo and Zola [19], these mixed teams seemed to benefit from the diverse backgrounds of students from different degree programs and these synergies were reflected in the project deliverables.

4.7 Teaching Both Courses Concurrently

There were both benefits and drawbacks to teaching both courses concurrently. Given that modules were identical for both the graduate and undergraduate courses this made manageable what would have otherwise been a decidedly challenging workload for the instructor. Given that the course design was biased toward graduate expectations with respect to course content and deliverables, however, it proved challenging at times for the undergraduate students. To compensate, during the most challenging projects of the course, undergraduate students were placed into one large group. Teaching concurrently also created opportunities for cross course critiques of student deliverables. At the conclusion of the semester there was a single critique session where students from both courses presented their video sketches, final concepts and project posters; each course learning and benefitting from the experience of the other.

4.8 Scalability

A logical question stemming from a discussion of our experience relates to scalability. Will this course, which covered significant subject matter but in two courses with fewer than ten students each, scale for a class of 20 to 40 students? In the present structure, we argue, the course *may* scale but with some degree of difficulty. Even with fewer than ten students the use of participatory design, which was a core component of the course, posed several logistical challenges. Our initial goal was to include the participatory design activities largely within course meeting times. It became evident early on that this would not be feasible given the transportation needs of our visually impaired co-designers and the relatively early meeting times of both courses. Setting these logistical issues to the side, additional students would also necessitate increased interest from persons within the visually impaired community willing to commit several hours of time for participatory design sessions over a period of at least a few weeks. While the use of participatory design was one of the major successes of the course, in subsequent iterations additional community support will be required to support the incorporation of participatory design activities in a course with more than ten students.

4.9 The Instructor Perspective

The creator and instructor of both courses was a new faculty member in their first year as a tenure track Assistant Professor of

Human-Centered Computing. The desire to develop both courses was motivated dually by what was viewed as weak point in the computer science curriculum and by the author's own research interests. Though the department at Clemson University has a Human-Centered Computing doctoral degree program, it was observed that there was an absence of courses at both the graduate and undergraduate level that specifically focused on issues of accessibility. While some of the department's existing human-computer interaction (HCI) courses contained modules that touched on accessibility, missing we argue was a course specifically focused on persons with disabilities, assistive technology and the techno-societal implications. Beyond this dearth of accessibility-focused courses the instructor was also motivated by his research interests and background. The instructor completed a master's thesis on social networking site accessibility and in a series of related papers explored the usability of Facebook by blind screen reader users [9] and the use of semantic web technologies [4] to address issues of inaccessibility. Within his doctoral dissertation he investigated the accessibility of fully autonomous vehicles for blind and low vision users and in resulting papers explored the opinions of visually impaired persons and older adults regarding autonomous vehicle technologies [5, 8, 11], implemented [7] and evaluated [6] an accessible autonomous vehicle human-machine interface, and made a series of policy proposals focused on autonomous vehicle accessibility [3]. Based on this background, teaching a course on inclusive design and accessibility seemed like a natural next step. In his Design and Research of In-Vehicle Experiences Lab (DRIVE Lab) the instructor focuses on the accessibility of transportation systems through projects with National Science Foundation and National Highway Transportation Safety Administration funding. Within this work he explores issues of accessibility in emerging mobility technologies and he has also conducted foundational research on the accessibility of fully autonomous vehicles.

While challenges developing and teaching such a course were anticipated, it was the instructor's belief that these challenges would be eased by prior teaching experience and an innate interest in accessibility. Prior to the course the instructor had two years as an adjunct at a two-year college developing new courses in software engineering and several years as a graduate teaching assistant. Despite the perceived teaching preparation coupled with a keen interest in the subject matter, developing both courses proved decidedly challenging. While the instructor was well versed in issues of accessibility from the perspective of visually impaired persons, he was less familiar with hearing, cognitive and motor impairments. It was necessary for the instructor to conduct an in-depth review of these topics in preparation for the semester relying upon the medical literature, recent research on related assistive technology, online videos and published literature reviews. Even with this preparation there was a student-noted difference in depth between the modules focused on visual impairment and blindness and those focused on the other disabilities covered within the course. Given student responses to the use of participatory design it would have been beneficial, perhaps, to have involved co-designers with disabilities less familiar to the instructor, such as persons with hearing or cognitive disabilities, to bolster the weaker modules. To do so, however, would have required community contacts beyond what was available to the instructor at the time. This approach would have also proved challenging in the sense that the instructor had considerable knowledge in creating visually impaired and sighted design teams and no prior knowledge of working with teams involving co-designers with motor, auditory or cognitive disabilities. While such teams might have had tremendous benefits in terms of student learning, there would have potentially been considerable tradeoffs with respect to recruiting, logistics and management beyond those already experienced. In future iterations of both courses every effort will be made to leverage relationships with organization for persons with auditory, motor and cognitive disabilities in anticipation of the use of participatory design.

5 CONCLUSION AND FUTURE WORK

Within this report we describe our experience teaching two courses concurrently on accessibility. We found that while students were challenged by the demands of the course, we were successful in supporting student learning objectives. By the conclusion of the semester students were able to both describe the characteristics of various disabilities and how they relate to computer and technology use while demonstrating a baseline ability to design technologies for use by disabled persons; demonstrated through design for persons visual disabilities. Through the semester projects which focused on mobility and emerging transportation technologies, students also left the course with a demonstrated understanding of the social aspects of computing and an understanding of the relationship between computing, accessibility and quality of life. These findings collectively suggest that stand alone courses focused on accessibility may prove effective at supporting the goal of introducing topics of accessibility to computer science students and students from related disciplines. Our findings also add support to research which advocates for the use of participatory design within the classroom context though we found that the use of participatory design may entail considerable recruiting and logistical challenges that should be considered for courses with more than ten students.

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