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A Teaching Case: A Seminar Course in Accessible Computing

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Abstract

Putnam et al. (2016) have published research indicating that accessibility is not well represented in higher education computing programs. Specifically, they observed having found only one documented case study of a program that included a specific course in which design and development of assistive technologies were the focus. In this paper, we share a teaching case describing a dedicated full-semester Accessibility Seminar in Adelphi University's graduate Computer Science program. We share our rationale for including an entire course in the curriculum, discuss its contents, and reflect on its success.

Keywords: accessibility, computing, curriculum, inclusion, teaching case

1. INTRODUCTION

Accessibility has become a significant concern for many Americans. Approximately 21% of U.S. residents who are 15 years of age or older have a disability of one kind or another (U.S. Bureau of the Census, n.d.-a). These disabilities can be visual, aural, physical, and/or cognitive and profoundly impact family income. While the median monthly family income in the United States was $4,432 in 2010, it was only $2,856 in families where the breadwinner had a disability (U.S. Bureau of the Census, n.d.-b).

In many ways, computers have been a significant part of the problem. For blind or visually impaired people, reading on a monitor or a screen can be very difficult or even impossible. Computer interfaces becoming increasingly graphical can put information beyond the reach of the blind and visually impaired. For the deaf, a good portion of the information they seek may be in the form of spoken words, making it inaccessible to the end-user.

Fortunately, computers are often part of the solution. Various screen readers are available that run on various platforms, including PCs running Windows, tablets, and phones running iOS or Android, as well as computers running Linux (American Foundation for the Blind, n.d.-a). In addition to using Braille printers (American Foundation for the Blind, n.d.-b); additionally, streaming video players usually feature closed captioning. However, these assistive technologies have their shortcomings. Screen readers do not share a common command structure; they may not work well with all programs and may not work with newer versions of some software packages. Braille printers start at $1,800 and can cost as much as $5,000 for small-volume printers. For the disabled, any assistive technology integrated into their computer or in software is usually better than technology added onto their computers. Fortunately, given advances in assistive technologies supporting blind and low vision people in using computers, computer science has become a more plausible career option than in years past (Huff, et al., 2021)

Part of the problem is that accessibility is not usually covered in a meaningful way in undergraduate or graduate computer science or information systems programs. We know of only a limited number of university programs with specialized courses in accessible computing. The institutions offering these programs include the University of Saskatchewan, the University of Washington, the University of Iowa, the Rochester Institute of Technology, and the authors' program). A cursory examination of online syllabi reveals that the topic is occasionally included in User Experience (UX) and Human-Computer Interactions (HCI) courses, which typically spend about one week on the topic. Many more schools do not address the subject of accessibility at all. A cursory examination of the requirements, descriptions, and syllabi for computer science courses at 33 New York area colleges and universities (excluding the author's school) showed that only twelve offered a course in Human-Computer Interaction or User Experience. Only one offered a course in assistive technology, and none offered a course in accessible computing. This anecdotal evidence aligns with the findings of Putnam et al. (2016).

There is a compelling reason that accessibility-related topics are commonly found in web design or web programming courses. Several lawsuits have targeted business and governmental agencies whose websites did not meet web accessibility standards. These have included Target Corporation (Parker, 2006), Priceline, Ramada Hotels (New York State Office of the Attorney General, 2004), Southwest Airlines (McCullagh, 2002), and the Sydney Organizing Committee for the Olympic Games (W3C, n.d.). The Individuals with Disabilities Education Act and Section 508 of the Rehabilitation Act have motivated educational institutions from kindergarten to universities to redesign their websites in order to improve their accessibility.

Outside of the Web Content Accessibility Guidelines (WCAG), there are no firm standards or guidelines that determine categorically whether software (other than webpages) is considered accessible or not. Software is generally not evaluated based on accessibility, nor is accessibility usually covered in software engineering or human-computer interaction courses.

Putnam et al. (2016) have published research indicating that accessibility is not well represented in higher education programs. Specifically, they found only one documented case study of a program that included a specific course in which the design and development of assistive technologies was the focus (p. 13:8).

This paper documents a teaching case (Cappel & Schwager, 2002) of an Accessible Computing Seminar in Adelphi University's graduate Computer Science program. We discuss the structure of the course and reflect on its outcomes after being offered several times.

2. BACKGROUND

Adelphi University is a private university in Garden City, New York, on Long Island. In Fall 2021, 5,251 undergraduate and 2,269 graduate students enrolled at the University. 1,883 of these students enrolled in the College of Arts and Sciences, which houses the Department of Mathematics and Computer Science.

The Department of Mathematics and Computer Science offers undergraduate programs in computer science, information systems, mathematics, and statistics. It also offers an M.S. in Computer Science and an M.S. in Applied Mathematics and Data Science at the graduate level.

The M.S. in Computer Science is a relatively new addition to the program portfolio. In 2016, the department's faculty set out to re-envision a modern graduate program in computer science. During that process, we envisioned a program that would be academically rigorous, societally relevant, and aligned with institutional priorities.

Adelphi University has long been a strong and vocal supporter of students with disabilities, as illustrated by long-existing programs such as the Learning Resource Program (LR) and the Bridges to Adelphi Program (Bridges). Adelphi established the LR program in 1979. Doing so created one of the first academic support programs in the United States, specifically targeting college students with learning differences. In 2007, Adelphi extended its services by launching The Bridges to Adelphi program, which supports students on the Autism Spectrum.

The first author has published prior work in accessible computing and expressed an interest in creating and teaching a course on the subject early in the new M.S. in Computer Science development phase. A course entitled "Accessible Computing Seminar" was included in the program as one of two courses to meet a particular requirement in the Software Engineering specialization; students in the other specialization

(Cybersecurity) can take the course as an elective that counts toward their 30-credit requirement.

While a few other schools have courses on accessible computing, they were not an original part of the degree program. In contrast, the Accessibility Computing Seminar at Adelphi University was created and included with the full backing of the Department and the University from the onset of the degree program. Other such courses came into existence only through the initiative of the instructor, and their inclusion was due to the instructor's research and/or their commitment to the subject (Putnam et al., 2016).

There are several challenges in creating a dedicated accessibility course: there is no textbook to adopt for such a course (although some potential instructors might find the book by Lazar, Goldstein, and Taylor suitable (Lazar et al., 2015)). Lazar et al. (2015) stated that the tendency of those teaching such a course to focus on their research or personal commitment could make it more difficult for the uninitiated to develop such a class. In addition to the lack of textbooks, there are few qualified and motivated instructors to teach such a course.

With accessibility becoming increasingly a focus in industry, inclusion of a seminar also helps students enter the professional job market with an advantage over peers who may be less knowledgeable about the topic.

The authors recognize that there is no uniquely correct or appropriate approach to developing a course on Accessible Computing. However, we believe that our experience is instructive for those looking to add this vital topic to a computer science curriculum.

The course offered at Adelphi University is not revolutionary, although it may be the only program where an accessible computing course was in the degree program's original design.

While developing the course, the author was aware of the courses taught at the University of Saskatchewan and the University of Iowa. Before designing Adelphi's course, we consulted Saskatchewan's Jim Carter and Iowa's Kyle Rector. Dr. Jim A. Carter is a Professor at the University of Saskatchewan whose research shifted from computer-human interaction to accessible computing. He created a course entitled, "Accessible Computing" and he wrote a textbook manuscript for this course. There are currently both graduate- and undergraduate level versions of the courses that are regularly scheduled at the University of Saskatchewan.

Dr. Kyle Rector received her Ph.D. from the University of Washington, and her advisors were Dr. Julie Kientz and Dr. Richard Ladner. Her area of research is improving the quality of life for the blind. She developed a course on Accessible Computing, which she taught at the University of Iowa.

The philosophy behind Adelphi's course is similar in many ways to Dr. Carter's and Dr. Rector's courses, although the specific content of the course differs in many regards. While there is no existing textbook, there are materials available from which to develop such a course.

3. ESTABLISHING THE COURSE

Adelphi University took in its inaugural cohort of students into the "Master of Science in Computer Science" degree program in 2018. The program launched, offering specializations in software engineering and cybersecurity.

A course entitled "Accessible Computing Seminar" was included in the program as a required elective, with the corresponding author as the instructor for the course. The course assignment was a natural fit based on the author's interest in teaching the subject.

The first author was already somewhat familiar with CMPT 480/840 (Accessible Computing), a course developed and taught by Dr. Jim A. Carter, an elective in the BSc and MSc program in Computer Science at the University of Saskatchewan. Carter's course had no exams; there were weekly interactive assignments, critiques on reading assignments, and a term project that the student proposed. The paper that Carter and Fourney (2007) wrote for the ASSETS conference described the course in detail.

A more extensive search of the World Wide Web led to the course CS4980 (Research and Development of Accessible Computing Technologies), which was developed and taught by Dr. Kyle Rector at the University of Iowa (Rector, K., n.d.). After a lengthy telephone conversation with Dr. Carter and a thorough examination of Dr. Rector's online materials, we decided to develop Adelphi University's course in a similar style to Dr. Rector's course. Our course proposal included two readings from Dr. Rector's course and three topics on Dr. Rector's syllabus: Disability and Design, Universal Design, and Assistive Technologies.

The author also consulted with the Assistant Director of the University's Student Access Office—responsible for accommodating students with disabilities—for additional feedback. He suggested that the term project should be rebuilding a website because it is one of the few areas in computing where there are clear guidelines indicating what is and what is not accessible.

The course now runs once per year, on a semester cycle. Fourteen weeks of instruction prepare students for one week of final exams or meetings. The established learning goals state that by the end of the semester, the students should be able to:

- discuss what a disability is and their classifications
- identify assistive technologies used by the disabled
- discuss the wide range of needs of disabled individuals
- discuss and apply significant legislation and regulations protecting the disabled
- apply the principles of universal design to web design and software design

4. COURSE OBJECTIVE

According to Adelphi University's online course catalog, "Students will learn about accessibility in the context of computer usage and study the distinction between accessibility and usability. Students will investigate the range of barriers to computer usage, explore adaptive technology and its use in systems, and review the development of accessibility guidelines and compliant system design." (Adelphi University Bulletin 2022-23, n.d.).

In effect, the objective of the course is to raise the awareness of accessibility among computer science students and to give them methods, tools, and techniques to ensure that software designed and developed by them will be accessible to a diverse group of users. Through the course, the curriculum evangelizes the need for inclusive design in all system design and system development aspects.

5. WEEKLY LECTURE CONTENTS

Table 1 outlines that the semester begins with eight lectures. It also includes examples of reflective paper assignments. With each lecture, students were tasked to write a reflective paper addressing one question arising from the lecture content. The expectation was a 2–3-page essay answering the question in hand. There was rarely a fixed answer to these questions; the point of the assignment was the process by which an answer could be reached, or an argument made that might sway the reader to a particular point of view.

Before students could effectively read the literature and work on a project that would allow them to see the difference that planning for accessibility can make, it was essential to include a basic introduction to disabilities and accessibility issues.

In addition to literature research, students engaged in a Website Project. It has evolved over the three years the course has run. In the first year, the class had the job of redesigning the author's web page to meet the new style of the University's website and to correct the content that violated the WCAG. In the second year, two students volunteered to create a website designed to violate as many checkpoints of the WCAG as possible. Changes were made to this site to increase the accessibility issues that students had to fix.

Week 1 – What Is a Disability

The first lecture covered the definition of a disability, the various types of disabilities, the degrees of severity, and the demographics. Students become aware of a broader range of disabilities than of which they are aware; they get to see the extent of unmet health care needs; and the unemployment and underemployment of the disabled, which can leave them in poverty. Moreover, they learn how these disabilities become more common as populations age. Several data sheets from the United States Bureau of the Census accompanied the lecture materials.

The reflective paper accompanying this lecture directs students to tour the campus looking for potential barriers to accessibility or accommodations that are present to eliminate these potential barriers.

Week 2 – Disability and design

The second week's lecture covers the intersection of accommodating a disability and either how to hide it or how to make a fashion statement about it. This lecture was based partially on Graham Pullin's book "Design Meets Disability." (2011). The lecture covered prosthetics and included some examples of this. These examples include accommodations and, in a few cases, enhancements, including artificial legs designed

to enable the wearer to complete track meets. It included a short history of wheelchairs, white canes used by the blind, eyeglasses, and hearing aids. It also included a series of photographs of Kaiser Wilhelm II of Germany, who created the illusion that his left arm—which was shorter than his right arm—was the same length as his right.

Students watched six videos in class discussing eyeglasses as a fashion statement, hearing aids, and artificial legs designed for Aimee Mullins. Ms. Mullins appeared at TED and spoke about the enhanced ability that her artificial legs gave her, including the ability to change her height.

Week	Lecture	Learning Objectives	Paper Assignment
1	Introduction	Student will be able to use basic accessibility terminology	What barriers to accessibility are there on campus? What features are there to eliminate, if any?
2	Disability and Design	Students will be able to discuss design options to address limitations imposed by disability in brief context of history	How do you feel about cochlear implants?
3	Disability and Accessibility	Students will explore the key impact of the Americans with Disabilities Act (ADA)	Do we need transportation infrastructure accommodation?
4	Assistive Technologies	Students will be able to discuss how assistive technologies can address some needs of people with disabilities	Do we need transportation infrastructure accommodation?
5	Disability Etiquette	Students will be able to interact with disabled people in a respectful way	Disability Etiquette Lessons From a Campaign
6	Disability and the Elderly	Students will be able to explain how aging impacts the use of technology	Are the Elderly Technophobes?
7	Universal Design	Students will be able to explain the principle of Universal Design	What makes a design universal?
8	Universal Design for the World Wide Web	Students will be able to explain how Universal Design principles apply to Web applications	Why Are So Many Web Sites Less Than Fully Accessible
9	Student Research		First round of papers – week 1
10	Student Research	Students will perform independent readings, present their findings, and engage in	First round of papers – week 2
11	Student Research	guided discussion with class members.	Second round of papers – week 1
12	Student Research		Second round of papers – week 2
13	Accessibility Project Lab		
14	Accessibility Project Lab	Students will apply lessons learned to a software prototype and present their results.	Demonstrating website – week 1
15	Project Demonstrations		Demonstrating website – week 2

Table 1. Week by Week layout of the Accessible Computing Seminar

Lastly, there was a video about a deaf woman who could hear her son's voice for the first time due to a cochlear implant.

The reflective paper asked students whether they would seek a cochlear implant for themselves or their child, given the controversy surrounding it.

Week 3 – Disability and Accessibility
The third week's lecture introduces the Americans with Disabilities Act (ADA), covering the employment of people with disabilities by providing, what the law considers, a "reasonable accommodation." It also determines the confidentiality of medical records and provides requirements for the accessibility of older buildings and new structures.

During class, students analyzed a case study in which journalist John Hockenberry was asked to leave a performance of a Broadway show because of his inability to walk. He subsequently wrote an article that appeared on the Op-ed page of The New York Times (1992). After the article appeared, the production reached out to him, and he was able to attend. In addition, students watched five videos covering various aspects of ADA.

The reflective paper assignment explored a comment by a columnist, who stated that it would be cheaper to pay for taxi rides for New York's disabled riders than to retrofit the Subway with elevators. Students had to take sides, arguing in favor or against the statement.

Week 4 – Assistive Technologies
Assistive technologies do not need to be high-tech, although many are. They can involve hardware, software, or a combination of both.

The lecture covered the definition of assistive technology, a brief history, and a review of the benefits they provide to those with disabilities. A point was made to stress that a significant fraction of people with disabilities have needs that the use of technology does not address. The lesson included examples of assistive technologies, including those used in education.

Students viewed five short videos in which four schoolchildren and one young adult with disabilities use computers and accommodations for work and recreation.

The sixth video was an item that had appeared on the CBS Evening News. In it, a middle school football team arranged a play that enabled a boy with a cognitive disability to score a touchdown. While the video did not show the use of assistive technology, it provides a clear example of empathy.

Given the expense associated with many assistive technologies, the reflective writing assignment tasked students to determine justifications for these devices and software expenditures.

Week 5 – Disability Etiquette
This lecture covered what one should and should not do in contact with the disabled. Examples include asking before helping, speaking directly to the individual with the disability, and keeping paths for the disabled clear. The lecture also dealt with some specific rules of engagement with people with specific disabilities.

Students watched videos highlighting specific instances where these rules were violated.

There were also three videos where Samuel Habib, a disabled college student, spoke to three Democratic presidential candidates before the New Hampshire primaries (Michael Bennet, Pete Buttigieg, and Joe Biden). While Senator Bennet and Mayor Buttigieg handled their interaction with Mr. Habib properly, Mr. Biden spoke to Mr. Habib in a manner generally regarded as condescending and even touched Mr. Habib's cheek. An analysis of this last interaction was the basis for this week's reflective paper.

Week 6 – Accessibility and the Elderly
The lecture begins with introducing demographic information to students to explain how large a percentage of the population is 65 and older and how the elderly represent a more significant proportion of the population.

The lesson also explores how the "baby boomers" continue to age and how their geographic distribution within the United States impacts society.

Students then discuss the diversity amongst the elderly based on age, independent living situations, age-related impairments, and other disabilities.

The discussion then transitions to their use of the Internet as an information source and a means of socialization and communication. Most students are surprised to see how much the elderly use the

Internet in general and the World Wide Web in particular.

The lesson is augmented by a few videos aimed at senior citizens explaining the use of various services. The videos also point out places they may go to access computers and the Internet if they do not have it in their homes.

The reflective paper assignment required students to reflect on the assumption that the elderly are technophobes.

Week 7 – Accessibility and Universal Design
Architect Ronald L. Mace (NCSU, n.d.) first used the term "Universal Design." He used it to refer to designing products and building environments that are accessible to all, regardless of age, ability, or status in life (University at Buffalo, n.d.).

To illustrate this concept, students consider a mundane example like a pair of scissors. Scissors are usually designed to be used by right-handed people, which makes them more challenging for left-handed people to use them. While it is easy to design left-handed scissors, it is more practical to design scissors that can be used in either hand with little or no adjustment before using them.

Students explore the impact of closed captioning on television. While broadcasts as early as the 1980s included close captioning services, the Television Decoder Circuitry Act of 1990 only first required television manufacturers to include the feature in televisions that were 13 inches or larger.

While separate captioning decoders were expensive, adding the capability to the circuitry of most new televisions had a minimal impact on most non-disabled consumers while providing a meaningful improvement to the deaf and hard of hearing.

The lecture covered several other examples of universal design that involve lavatories, public telephones that included teletypes, and the ergonomics of the workplace.

The lecture also included two articles to read on the subject and four videos defining universal design and its benefits.

The reflective paper asked the students to think of a product whose design could be universal and why they considered it as such.

Week 8 – Accessibility and the World Wide Web
This week's topic focuses on the positive outcomes experienced by many users when accessibility standards are appropriately adopted. The lesson emphasizes that adopting such standards does not impose a disproportional burden on developers. In addition, students review the legal obligation to develop accessible software.

The World Wide Web consortium issued the first version of the Web Content Accessibility Guidelines (WCAG) in 1999 (W3C, 2000) and released the second version in 2010 (W3C, 2010). They have begun work on version 3 (W3C, 2021).

There is a sizeable body of evidence that many websites do not meet these guidelines (Lazar et al., 2003; Siegfried et al., 2010).

Students learn about the various guidelines of the WCAG. For example, students explore how some color contrasts meet the guidelines, but some do not.

As part of the class, students will use software tools to determine how accessible a website is. This activity introduces them to a software project in which students analyze a website with many accessibility issues and redesign it so it will meet most WCAG requirements.

The students in the class review five websites that go into considerable detail about web accessibility standards and view four videos on the topic.

In the reflective paper accompanying this lecture, students must answer the question: "why are so many websites inaccessible?"

6. PAPER PRESENTATIONS

Accessibility is a relatively unexplored area in computer science. As such, by studying academic papers from the computer science literature, students discover concepts that are not yet fully available in industry.

The instructor assigned two separate rounds of literature reviews to the class. Each review focused on one topic. In the first round, students study programmers who are blind. In the second review cycle, students explore web accessibility.

In the mid-1960s, the University of Manitoba created a course for the specific purpose of training programmers who were blind. Since

then, the blind have found programming a reasonably accessible profession. However, the popularization of graphical user interfaces (GUIs) has hindered the efforts of blind programmers to work in this field (Alexander, 1998). Several recent articles have discussed tools developed to aid the Blind when writing source code (Albusays et al., 2017; Baker et al., 2019; Schanzer et al., 2019; Schanzer et al., 2020). Each student in the class was assigned a paper. The instructor tasked them to create a 2-3 page summary of the paper and to present it to the other students in the course.

The second round of papers addressed the accessibility of web pages; the fact that there are clear guidelines that have been in effect for two decades made this a topic of interest. An additional collection of articles was assigned, one per student, requiring an in-class presentation and a summary paper.

7. ASSESSMENT

Since the course has only run three times to-date, only limited assessment has occurred. As a result of the COVID-19 pandemic, student evaluations are minimally available. The few students that evaluated the course were generally positive. Anecdotal evidence suggests that students are more aware of the need for accessible design after completing the course. However, we could not collect sufficient student feedback to make statistically relevant observations.

A more effective—and potentially more objective—method for course evaluation is by inspecting artifacts that students produced and rating them against a common rubric.

Of a total of n=208 artifacts produced in three semesters, a sample of four works per semester were inspected and analyzed. The artifacts consist of reflective papers, presentations, and term projects. The artifacts reflected that some students took the teaching to heart. For example, in several inspected artifacts, students struggled with the moral question regarding how appropriate it is for a deaf parent to choose whether their child would receive cochlear implants. In another artifact, students played the role of a school administrator who determined the budget for accessible technologies. Students raised arguments from morality and inclusion to simple business sense to argue that assistive technologies must be supported. All these artifacts indicate a raised awareness of disabilities, and the role technology plays in alleviating some of the disadvantages caused by them.

Another artifact, a website project, demonstrated how a website became much more accessible after applying accessibility standards. If taken to heart, these lessons will remain with a student as they prepare for a career in software engineering.

Lastly, course enrollment is a minor indicator of student interest in the topic. Since this is an elective course, students are not required to take it. However, the three years we have offered the course have consistently attracted a healthy enrollment. An argument can be made that this reflects positive student interest in the subject matter.

8. CONCLUSIONS AND FUTURE WORK

In this paper, we set out to fill in a gap in publicly disclosed curricula identified by Putnam et al. (2016). This paper shares the objective, design, and outcomes of a computer science course that raises awareness of accessibility among graduate students. By doing so, we hope that modern computer science curricula embrace the vision that computing must really be for all, regardless of ability.

Our goal is to move past the sharing of the existing curriculum and to continue research in this field. We will continue to collect data regarding the effectiveness of the course and provide ideas for inclusive course design.

Furthermore, we intend to look past limitations imposed by physical disabilities and want to include exploration into ways in which people with neurodiverse learning styles use and learn computing-related technologies.

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