"*It could be better. It could be much worse*": Understanding Accessibility in User Experience Practice with Implications for Industry and Education

CYNTHIA PUTNAM, College of Computing and Digital Media, DePaul University
EMMA J. ROSE, School of Interdisciplinary Arts & Sciences, University of Washington Tacoma
CRAIG M. MACDONALD, School of Information, Pratt Institute

While accessibility is acknowledged as a crucial component in design, many technologies remain inaccessible for people with disabilities. As part of a study to better understand UX practice to inform pedagogy, we analyzed 58 interview sessions that included 65 senior user experience (UX) professionals and asked them "How do you consider accessibility in your work?" Using transitivity analysis from critical discourse analysis, our findings provide insight into the disparate practices of individuals and organizations. Key findings include the growing role of design systems to structurally address accessibility and the range of organizational strategies, including dedicated teams. We also found that the categories of accessibility consideration were somewhat superficial and largely focused on vision-related challenges. Additionally, our findings support previous work that many practitioners did not feel their formal education adequately prepared them to address accessibility. We conclude with implications for education and industry, namely, the importance of implementing and teaching design systems in human-computer interaction and computer-science programs.

CCS Concepts: • **Human-centered computing → Empirical studies in accessibility**;

Additional Key Words and Phrases: Accessibility, design systems, user experience practice, industry practice

ACM Reference format:
Cynthia Putnam, Emma J. Rose, and Craig M. MacDonald. 2023. *"It could be better. It could be much worse"*: Understanding Accessibility in User Experience Practice with Implications for Industry and Education. *ACM Trans. Access. Comput.* 16, 1, Article 9 (March 2023), 25 pages.
https://doi.org/10.1145/3575662

1 INTRODUCTION

There is an increasing awareness within the **Human-Computer Interaction (HCI)** and **User Experience (UX)** disciplines that well-designed digital technologies should be usable by everyone. When a product is designed with the needs of people with disabilities in mind, it often creates benefits for all people; when it is not, it prevents entire groups of people from participating in our digital society. Further, the number of people who are disenfranchised by inaccessible technologies

We thank DePaul University for funding this work.
Author's addresses: C. Putnam, Jarvis College of Computing and Digital Media, DePaul University, 243 S Wabash Ave, 4th Floor, Chicago, IL 60604; email: cputnam@depaul.edu; E. J. Rose, University of Washington Tacoma, Box 358436, 1900 Commerce St, Tacoma, WA 98402; email: ejrose@uw.edu; C. M. MacDonald, Pratt Institute, School of Information 144 West 14th Street, 6th Floor New York, NY 10011-7301; email: cmacdona@pratt.edu.

1936-7228/2023/03-ART9 $15.00
https://doi.org/10.1145/3575662

is large. The US Centers for Disease Control and Prevention estimated that one in four people in the United States live with some type of disability [19]. Unsurprisingly, there is a large digital divide between people with and people without disabilities. A 2016 survey by Pew Research Center found that about 23% of people who were disabled and live in the US reported never going online compared to only 8% of those who do not have a disability [11]. These estimates are not confined to the US, as the World Health Organization estimated in 2014 that more than one billion people worldwide cannot visually consume website content due to visual impairments [22]. However, over the past two decades there have been some significant innovations by companies to make their products and services more accessible to wider audiences.

Examples include Facebook's Automatic Alt Text, which provides descriptions of photos for their users who are blind [61], Amazon's "Show and Tell" feature for Alexa that enables an Echo camera to identify objects held to the camera [67], and Microsoft's adaptable game controller for Xbox that addresses mobile accessibility [13]. These are but a few of the encouraging advancements resulting from: (a) practical reasons, i.e., acknowledgment of the good business case of inclusion so more people can buy and use their products/services [56] and avoidance of court cases due to noncompliance to laws such as the Americans with Disabilities Act [3] and (b) ethical reasons, i.e., ensuring that everyone is treated equally and provided the same opportunities, thus contributing to a fairer society [30]. While we can point to inclusive design successes, there are still far too many technologies that are not accessible to people with disabilities.

For example, results of an accessibility evaluation in 2022 by WebAIM of the top 1 million websites using the **Web Content Accessibility Guidelines (WCAG 2.0)** found an average of 50.8 conformance failures per page [10]. Further, in our experience as HCI educators in the US, accessibility is too often reduced to superficial components such as color contrast, covered as an elective rather than as a required course, or taught as an optional step near the end of the User-centered Design process rather than integrated into the process from the start. A lack of emphasis on accessibility by HCI educators is certainly not the only reason so many inaccessible technologies exist, but how and to what extent accessibility is integrated into HCI (and computer science) curricula can play a big role in inspiring future design and computing professionals to adopt more inclusive practices and advocate for designing more accessible technologies.

Considering these trends, we set out to better understand how UX practitioners approach accessibility as part of their practice to inform the design of HCI and **computer science (CS)** curricula. To do so, we analyzed data from 58 interviews sessions with UX professionals (between summer 2017 and spring 2020) who worked in agencies, consultancies, or in-house UX teams throughout the United States. Our questions spanned a wide range of topics that included participant backgrounds, their workplace communication practices [42], what they desired when hiring new graduates [58], and how people with disabilities were considered in their products. This article is focused on the latter topic of accessibility and builds on our previous research from 2012 that also examined how UX practitioners included accessibility in their work [55]. This work has two key contributions for HCI/UX practitioners and educators in both HCI and CS: (1) We share how companies have successfully incorporated (or not) accessibility and inclusive design/research, revealing potentially insightful methods practitioners might consider adopting, and (2) we expand on the literature focused on teaching accessibility at the university level, providing additional guidance for educators concerned with preparing students for UX careers.

This article is organized as follows: First, we review the related literature on (a) how UX practitioners approach accessibility and (b) on teaching accessibility. Second, we provide an overview of our research methods, including recruitment, data collection, and data analysis. Third, we present findings organized by key questions outlined in our methods. Fourth, we discuss the data and its

implications for industry practitioners and educators. We conclude by discussing limitations and future work.

2 RELATED LITERATURE

There are two key vectors of literature related to this article: (1) research into accessibility considerations in industry and (2) research concerned with teaching accessibility to prepare students for industry.

2.1 Accessibility Considerations in Industry

While there has been some research of UX professional practice to inform pedagogy (e.g., References [17, 53, 58]), examinations focused on accessibility considerations among practitioners is a less-studied area. In an early example in 2004, Lazar et al. [38] interviewed developers responsible for web pages ("webmasters") and found that barriers to accessibility consideration included lack of time and lack of managerial support. In a 2012 survey of people with a wide range of industry job titles, researchers reported that while most respondents (70%) reported that they considered accessibility, most of those considerations were limited to more superficial concerns (e.g., alt text) [55]. More recent studies support these earlier findings of minimal accessibility considerations.

In 2022 paper, Bi et al. [15] interviewed (n = 15) and surveyed (n = 365) software engineers from around the world, asking how they perceived and addressed accessibility. They found that only 30% of their participants had accessibility-related work experience and most lacked the knowledge to apply accessibility considerations. Organizational factors, such as a lack of time and budget, were cited as major reasons for their participants' inability to integrate accessibility throughout development lifecycles. Related, Liete et al. [39] investigated accessibility awareness among 830 mobile developers in Brazil in 2021, finding that accessibility considerations were only fully adopted by about 22% of their respondents.

Researchers have also examined developers' practices with the goal of creating predictive models to help identify factors influencing the adoption of accessibility guidelines. In one example of model building, Velleman et al. [71] conducted 18 interviews in 2013 with stakeholders responsible for creating web-based content. They found that four factors impacted full implementation of accessibility guidelines that included their web design processes (e.g., accessibility knowledge), organizational factors (e.g., prioritization of accessibility and available resources), personal factors (e.g., perceived complexity of accessibility adoption), and external factors that included technical complexity. In another example of predictive model building from 2012, Nahon et al. [46] used data from 417 survey respondents from the US and Canada. Significant predictors of intending to create accessible web content in their model included personal factors (e.g., attitude towards accessibility) and external factors (e.g., legal requirements).

Tools that facilitate accessibility evaluation and training have also been a related research focus. In an early study that considered tools, Trewin et al. [70] surveyed 49 IBM web developers in 2010, finding that their participants felt automated accessibility evaluation tools were difficult to use and were prone to false negative and false positive errors. More recently, Snider et al. [66] examined questions employees submitted about accessibility at a large multinational corporation over a two-year period. They found that about two-thirds of the questions were answerable by an automated system if designed using a properly developed machine-readable representation of domain concepts, i.e., an ontology. In their paper, the authors introduce their ontology aimed at this goal. Shinohara et al. [64] approached the concept of training tools using method cards that depicted real-life scenarios involving people with disabilities. They tested their cards with student designers and found that the cards helped the students create more accessible designs and more appropriately engage with deaf and hard-of-hearing participants.

Another small but important area of research is the study of accessibility experts who are embedded in technology companies. In 2018–'19, Azenkot et al. [12] interviewed accessibility experts in industry who represented 13 companies. The experts performed roles in educating, managing, and mentoring co-workers. Echoing previous findings of the pivotal role of advocates, a key takeaway from this work was how few practitioners were responsible for promoting the creation of accessible products across large and small companies. Additionally, many of their participants did not feel they received sufficient training in their formal education to become accessibility experts.

Concurrently, there is a gap between qualified candidates to fill accessibility positions in industry and the available talent pool. A 2017 survey conducted by the Partnership on Employment and Accessible Technology with 70 respondents [2] found that 93.5% of tech companies reported it was "very important" to hire employees with accessibility skills, while 60% related that it was difficult or very difficult to find employees who had the skills and knowledge needed. Aiming to examine what practitioners learned in school about accessibility, Patel et al. [50] surveyed 77 professionals and conducted 10 follow-up interviews. Participants felt that their formal education did not adequately prepare them for accessibility. Similarly, a 2018 WebAIM survey of 724 accessibility practitioners found that only 5.5% of respondents reported learning about accessibility in their formal education [8]. In the next section, we present a brief review of the literature related to teaching accessibility.

2.2 Teaching Accessibility

It is recognized by many educators that proficiency in accessibility-related skillsets should be part of CS and HCI programs [52]. This is underscored by the Teach Access initiative [9], which emphasizes the importance of educating students about accessible computing. Teach Access is a collaboration among multiple tech companies, disability advocacy organizations, and universities. Related literature in teaching accessibility is commonly presented through the lens of first-person(s) experience(s) in which a reader can find guidance for their own courses and programs [18, 35, 37, 40, 43, 54, 73].

In recent examples, El-Glaly [24] discussed a course designed for software engineering students, Kelly and El-Glaly [34] presented modules they had designed to teach about accessibility to high school students, and Gabbert [26] reported on the experience of including accessible-related topics in an introductory CS course. Walther and Sonka [74] presented an abstract of their experience in the design of a week-long summer study program that included both faculty and students from seven universities. Their program included teachings from accessibility experts who worked in Silicon Valley.

While these experience reports are valuable in sharing ways to include accessibility topics in teaching, it can be difficult for readers to assess the relative efficacy of the varied approaches and interventions. Zhao et al. [78] aimed to address this concern through a four-year longitudinal study that examined 29 courses taught by 10 different instructors to compare the relative efficacy of various teaching interventions on student learning. The authors found that all interventions were successful to varying degrees at raising students' disability awareness over the short-term, but that a single course did not produce lasting knowledge. This finding indicated a need for considering systematic integration of accessibility topics throughout programs.

However, systematic integration throughout programs is uncommon. One notable exception is the University of Dundee's CS undergraduate curriculum. Waller et al. [73] provided a detailed description of their four-year program in which accessibility topics are interwoven as a focus in multiple courses. Similarly, Sonka et al. [67] report on their experience situating accessibility as the core focus in the undergraduate degree in Experience Architecture at Michigan State University. At the graduate level, Kang et al. [31] describe the **Research and Education in Accessibility**

Design and Innovation (REDi) program at Carleton University. The program is a five-part training program to prepare students for careers in accessibility research and design. In each of these examples, the authors were largely responsible for driving the high level of accessibility integration in their programs. We have found that the reliance of strong advocates is common in the literature about teaching accessibility topics.

The importance of advocates is present in Bohman's 2012 doctoral dissertation [16], which examined how accessibility was taught across three Master's of Science Programs, focused on accessible computing located in Austria, UK, and the US. Bohman found that the existence of all three programs was largely due to a few instructors who advocated for their creation. The importance of accessibility advocates was also evident in our work in which we interviewed instructors who teach accessibility in the US [51]. In that paper, we argued that the reliance on accessibility advocates limits the scalability of accessibility topic inclusion in CS and HCI curricula. However, expanding beyond advocate-driven curricula requires that educators feel confident in including accessibility-related topics in their courses and programs.

Unfortunately, research has indicated that many educators perceive barriers to including accessibility in their teaching. Shinohara et al. [65] conducted an extensive survey with over 1,800 respondents who teach CS topics. While most (53%) agreed or strongly agreed that accessibility should be taught, there were two main barriers for teaching accessibility: (1) the topic was not considered a core part of the curriculum at the administration level and (2) they did not know how to teach it. Aiming to address the latter barrier, Ladner and May [36] held a workshop at the **Technical Symposium on Computer Science Education (SIGCSE'17)** targeted at helping instructors new to accessibility learn how to include related topics in their programs and classrooms. Other calls for training include work by Kawas et al. [32] who conducted interviews with 18 Computer Science faculty with the aim of exploring the feasibility of a "micro" professional development model for teaching accessibility. The goal of these efforts (of course) is to increase accessibility practices in industry.

To summarize this literature review, there is an acknowledged importance of including accessibility in CS and HCI curricula. The inclusion of accessibility topics is very often the result of a small group of advocates and there has been more focus in recent years on instructor training in accessibility for increasing scalability and potentially more systematic inclusion. Studies of accessibility considerations among professionals in industry who are not experts found that there was minimal regard due to barriers, which included lack of resources, no managerial support, and difficulties using available tools. Insufficient training in formal education was cited as a barrier by both accessibility experts and non-experts. Concurrently, many in industry have expressed desire for more accessibility expertise among potential candidates. Our study builds on this work by exploring how companies have successfully incorporated (or not) accessibility and inclusive design/research, revealing potentially insightful methods practitioners might consider adopting and educators may consider incorporating in their HCI and CS curricula. In the next sections, we present the methods, findings, and discuss the implications of the research.

3 METHODS

In the following sections, we describe our participants and our data collection and analysis methods. Note that data analyzed in this article was collected as part of a larger project to gather insights into UX professional practice to improve HCI curricula and pedagogy in our undergraduate and graduate programs.

3.1 Participants

We used a combination of snowball and convenience recruitment methods, including social media posts, messages on Slack channels, and email lists of UX professional associations, word-of-mouth,

Table 1. Breakdown of Interview Phases and Sample Size

	Interview Sessions	Individuals Included
Phase One: June–August 2017	6	12
Phase Two: December 2018–February 2019	10	11
Phase Three: April 2019–April 2020	48	48
Initial Total	**64**	**71**
Recording Failures and question not asked	(−6)	(−6)
Total sample for this article	**58**	**65**

and direct messaging on LinkedIn. Our inclusion criteria required participants to have at least five years of UX industry experience and at least six months in a senior role. We chose these criteria to ensure our sample included individuals who could speak knowledgeably about the full scope of their organization's UX practices.

Participants in our final sample had, on average, 13.5 years of total industry experience and 3.75 years of experience in their current role. Almost two-thirds of our participants (63%) held managerial positions, with the remainder being individual contributors (24%) or internal or external consultants (13%). Sixty-one percent of our interviews were with professionals working on in-house UX teams, while the remaining 39% worked for agencies or as independent consultants. All our participants worked for US-based companies at the time of the interview; the US focus was intentional, given that our students are likely to work for US-based organizations after graduation. All but three participants were also living in the US, with a roughly even distribution between the East Coast (36%), Midwest (28%), and West Coast (28%). We did not ask our participants if they had a disability, and no one offered this information on their own.

Participants held a variety of job titles, but the most common titles included "Director" (of UX, of Design), "Senior" (UX Researcher, UX Manager), or "Lead" (UX Designer, UX Architect). In terms of focus, participants were also roughly split between design-focused roles (32%), research-focused roles (25%), and roles that included both design and research (27%). Finally, many different industries were represented in our sample, including software (n = 6), financial services (n = 5), e-commerce (n = 4), medical devices (n = 4), and healthcare (n = 4), among many others.

3.2 Data Collection

In total, we conducted 64 interview sessions with 71 individuals between June 1, 2017, and April 1, 2020, through three phases (see Table 1). Although we conducted 64 interview sessions, our final sample for this analysis included only 58 interview sessions, because we had 5 technical recording failures in phase three (in which 4 interviews were not recorded at all and 1 was only partially recorded) and the question was not asked in 1 interview due to time constraints.

Interviews were semi-structured and typically lasted for 60–70 minutes. We selected our questions based on what we wanted to learn for our teaching. Questions spanned a wide range of topics that included participant backgrounds, their workplace communication practices, good and bad project experiences, what they desired when hiring new graduates, and how accessibility was considered in their products. In this article, we focus only on analyzing segments from participant responses about their accessibility practices.

To account for differences in time zones and for participant preferences, interviews were conducted via remote video (66%), in-person (20%), or phone (14%). All interviews followed the same protocol regardless of format, and we did not detect any difference in content, quality, or length between the different interview formats. All participants received a $30 gift card.

3.3 Data Analysis

To frame our analysis, we borrowed concepts from transitivity analysis, which is a type of critical discourse analysis [42]. This approach is similar to qualitative coding data applied in other CS-related research contexts (e.g., see Reference [75]). Transitivity analysis is described as "the study of what people are depicted as doing and refers broadly to who does what to whom and how" (Reference [42], page 104). For this article, we examined two aspects of transitivity analysis: (1) material processes and (2) mental processes.

Material processes describe the doing of concrete actions. The two key components are the actor(s) (the doer(s)) and the goal of their actions. Material processes can also have beneficiaries. Mental processes are divided into three classes: (1) cognition (verbs of thinking, knowing, or understanding, (2) affection (verbs of liking, disliking, or fearing), and (3) perceptions (verbs of seeing and hearing). We considered the first two mental processes, feeling the third was not applicable to this study, because we did not ask about direct perceptions such as seeing or hearing in our interviews.

First, we applied attribute (e.g., education, type of industry) and structural coding [56] to the interview transcripts using Atlas.ti. Then, the first author applied the transitivity framework to the interviews to create an initial codebook. Specifically, for material processes, we asked six key questions pertaining to concrete actions:

(1) How did participants discuss the concrete actions that were taken at their organization (or with their clients)?
(2) What were the categories of actions?
(3) Who was responsible for taking those actions (i.e., actors/doers)?
(4) Who were the mentioned beneficiaries of actions taken?
(5) What were the major drivers of action?
(6) What were the drivers and reasons given for non-action?

We coded our interview transcripts for mental processes by asking two key questions:

(1) What was their cognitive awareness, i.e., how knowledgeable did they speak about concrete actions focused on accessibility at their organization (or their clients' organization)?
(2) What was their emotional reaction (if apparent)?

Once the initial codebook was created by the first author, we met to discuss. The other two authors then applied the codebook to a subset of the transcripts. After minor adjustments, we re-applied the codebook to question: "how was accessibility considered in your work?"

4 FINDINGS

We organized the findings section into material and mental processes. We only report on material and mental processes that were coded in at least three interview sessions (5% of the 58 recorded transcripts). Quotations were lightly edited for clarity.

4.1 Material Processes

Among the 58 interview sessions (involving 65 participants), 44 (76%) claimed awareness, even if they were not personally involved, of at least some actions taken by their organization (or clients) towards making products and services accessible. We organized the material processes by the six key questions described in the methods section.

4.1.1 How did Participants Discuss the Concrete Actions that were Taken at their Organization (or with their Clients)? We identified four common concrete actions participants recalled

Table 2. Common Ways Our Participants Discussed Concrete Actions Taken

Concrete Actions	Number of Interview Sessions (out of 58)
Design systems and pattern libraries	28
Usability testing with people who have disabilities	18
Training including simulation labs and workshops	7
Coding	5

addressing accessibility: (1) design systems, (2) usability testing, (3) training, and (4) code considerations, summarized in Table 2.

The most common response (48% of interview sessions) as to how companies were considering accessibility was the adoption of a design system—sometimes referred to as component and/or pattern libraries—where accessibility was coded in reusable components. P30, a UX design consultant who was embedded at the time of the interview at a financial service organization told us:

> "Accessibility is done at the design system level…so they have baked into it."

P54, an in-house design director at a large insurance company that catered to elderly consumers, used the term "design language system" when asked about how their company considered accessibility:

> "We have a design team that's just devoted to a design language system. Every component in that design language system is accessible. We have like a couple people who are highly expert in that regard. We have accessibility reviews. We follow a process …you can use a design language system as a governance mechanism within an organization … it's a big deal."

There was a notable trend in the mention of design systems to facilitate accessible technology through the three interview phases. Among the six phase-1 interview sessions conducted in 2017, design systems were mentioned in 2 (33%), among the 10 phase-2 interview sessions conducted in late 2018, and early 2019 design systems were mentioned in 4 (40%), and in the last 42 successful recorded phase-3 interviews (in which the question was asked) conducted between November 2019 and March 2020, design systems were mentioned in 22 interviews (52%). This suggests that the adoption of design systems appears to be increasing over time.

Inclusion of people with disabilities in usability testing was another common response, mentioned in 18 (31%) of the interview sessions. P51, an in-house Director of Design Ops at a restaurant service organization, discussed testing as integral to assuring that their design system components were accessible:

> "If we're using [design system] components and we know those components are accessible. There was testing done yesterday with blind users where they have them try to complete tasks. We're trying to again stay focused on not just being compliant, but also highly usable."

Seven interview sessions (12%) included discussion about how their organizations invested in training, which often included simulation labs or workshops to help educate employees about accessibility. P19, a researcher working in government, told us:

> "We can't create anything that's not accessible…they poured a lot of money into this… actually have a full half floor…we call it an empathy lab and it's like an

Table 3. Categories of Concrete Actions

Concrete Action Categories	Number of Interview Sessions (out of 58)
Color and color contrast	23
Text size	7
Accessibility for mobility disabilities	6
Alt text for images	5
Use of ARIA in web-based coding	4

> accessibility lab of like different screen readers, different devices, legacy devices, um, even like vision impairment goggles."

Finally, the importance of code was emphasized in 5 (8%) interview sessions, often in relationship to design systems. P39, a Director of UX Design and Design Operation for a financial planning organization who was responsible for bringing design systems to their company, spoke of accessibility as related to code:

> "We were always told 'design needs to fix this.' If you are talking about a contrast level…that is fine. But really, this is a coding problem. 90% of this is a coding problem, 10% of it is a design problem. Every company I've ever worked in believes it's a design problem and it's not. It's a code problem. So within the design system we're able to solve accessibility to the extent of the components."

4.1.2 What were the Categories of Concrete Actions? To better understand what specific actions are attended to in support of accessibility, we identified five common categories: (1) color, (2) text size, (3) mobility, (4) alt text, and (5) **ARIA (Accessible Rich Internet Applications)**, summarized in Table 3.

Color and color contrast was mentioned in 23 (40%) interview sessions. P28, a Senior Product Designer who worked in-house for an organization focused on educational products, discussed how their company transitioned from print to digital deliverables:

> "A lot of the first round of visual designers and UX designers were actually print designers…we found that they were doing a lot of web technical systems design based on print mentalities. You have these very beautiful faint grays on even fainter grays. It's very subtle and I ended up doing this entire road show of accessibility and we do a lot of exercises to just show them this is painful for someone who has low vision, which is a huge chunk of the population."

The second most common category of concrete action was in text size, mentioned in 7 (12%) interview sessions, often discussed at the same time as color, color contrast, and alt text for images (mentioned in 5 interview sessions—8%). For example, in 1 of the 6 interview sessions in which a participant discussed accessibility unprompted (prior to our questioning) P15, a Founder of a Research Consultancy, described their experience working with a large company:

> "I was probably the only person, me and [co-worker] who knew anything about accessibility.… we needed to determine if their site is accessible. I would just look at the site, look at the fact that the fonts were small. Contrast was terrible. Um, you know, they didn't have any alt text in the images…"

In 6 (10%) of the interview sessions, participants discussed mobility-related categories of actions their organization had taken. P62, a Senior UX researcher at an automotive company, discussed

Table 4. Who Was Responsible for Actions?

Concrete Actions by Whom (Doers)	Number of Interview Sessions (out of 58)
Specialist and dedicated teams	15
Engineers and developers	14
UX and research teams	9
Everyone	4

how their products needed to consider drivers with a range of mobile abilities after discussing color considerations for people with color blindness:

> "We consider color combinations…you know for color blind people for instance. Another area is people who have mobility impairments… we might be thinking about how hard it is for some people to be able to reach…[and] use a button."

The last common category was the use of **ARIA (Accessible Rich Internet Applications)** tags and roles in web-based products. P43, a UX Manager who worked for an organization within the US federal government in which accessibility is highly reviewed, included ARIA when discussing some challenges of hiring an external consultant to help with user testing and creating data tables:

> "We learned to test in the way that she [external consultant] was testing so that when we were passing something off for review… we could reproduce her work. ARIA tags are there as much as we possibly can. And we absolutely provide an unglamorous, unsatisfying (in my opinion) flat HTML table that has all of the data behind it."

4.1.3 Who was Responsible for Actions Taken? We identified four major categories of actors who are responsible for accessibility: (1) specialists and dedicated teams, (2) engineers and developers, (3) UX-ers, and (4) everyone, summarized in Table 4. There was some overlap in the first three categories, i.e., it was not uncommon for participants to mention multiple roles as responsible, including developers and UX-ers.

In 15 (26%) interview sessions, participants conveyed that they used accessibility specialists and dedicated teams. In 2 cases, the teams were external consultants. In an example of an internal team coded for both this category and developers, P57, a manager of UX at a software company whose products are for the public, answered:

> "We have an accessibility team in engineering that works on making the [product] accessible and improving on that. They were like a source of support for everyone making a feature accessible but designers or UX were not involved too much in depth."

In 14 (24%) interview sessions, participants told us that engineers and developers were responsible for making their products accessible. P3, a Manager of UX at a consulting agency, relayed how developers at their company were responsible:

> "A fair amount of that gets handled within the development side of it. It's a little bit more difficult for us in the sense of like doing it from a client standpoint. You have to work with whatever [company] provides for you."

In 9 (16%) of the interview sessions, participants identified UX-ers and researchers as those responsible for acting on accessibility. P58, a Senior Interaction Designer at an engineering consulting firm, told us:

Table 5. Who Were the Beneficiaries of Actions Taken?

Who benefited from concrete actions?	Number of Interview Sessions (out of 58)
Blind, low vision, and color blind	27
Deaf and hard-of-hearing	7
Mobility impairments	4
Cognitive disabilities	4

> "We have to lead the charge on that. When I was hired, I did a shorter project that was an accessibility assessment for a transportation app that was needed, that was used specifically by people with disabilities. It wasn't my domain of expertise. So, I had to learn a lot there. I was able to conduct some usability studies with blind people. We were producing an app for a Fortune 100 [company] and a client that was consumer-facing in the health market. Nobody had talked about accessibility at all. I was like, 'this is going to market and in two months we need to do an accessibility review.' And we did it, we caught some things."

The last major group responsible was described as "everyone" in 4 (7%) interview sessions. P20, a Senior Product Designer at a public-facing organization concerned with health, said:

> "I would say it's like a shared ownership. Like everything. Every team, especially in visual design too, in terms of color contrast, that's something, yeah…that they must account for. And then considering light mode, dark mode, those kinds of different scenarios as well."

4.1.4 Who were the Mentioned Beneficiaries of Actions Taken? We identified four common categories of the beneficiaries of actions, people who: (1) are blind, low vision, colorblind, (2) are deaf and hard-of-hearing, (3) have mobility impairments, and (4) have cognitive disabilities, summarized in Table 5.

By far, the most common beneficiaries of actions taken were people with vision impairments, mentioned in 27 (47%) of interview sessions. The second most common beneficiary group conveyed in 7 (12%) of interview sessions were people who are deaf and hard-of-hearing. In an interview coded for both, P19, who was a User Researcher at a government-funded healthcare organization, said:

> "For a service like ours where we are taking it incredibly seriously, so we're not building something and then sprinkling on some accessibility stuff on from the start. We've kind of had to make assumptions and test our hypotheses for people with vision and hearing impairments."

People who have mobility impairments and those with cognitive disabilities were each coded in 4 (7%) interview sessions. P36, a Director of Mobile App Development at an agency that created products for healthcare, spoke of including people with mobile disabilities, low literacy rates, and concerning color blindness in their user testing:

> "We do try, with the medical human factors stuff, take into consideration when we're recruiting people with hand dexterity if it's an auto-injector or something where pretty much any medical device you have to hold somehow, so then also for instructions for use, colorblind, and just low education… medical literacy. We try to take into consideration all of those things when we're recruiting."

Table 6. Common Drivers of Concrete Actions

What were the drivers of action?	Number of Interview Sessions (out of 58)
Compliance to standards	18
Government organization or government funded	10
Public-facing	9
Maturity	5
Lawsuits	4
Individual advocates	4

4.1.5 What were the Drivers of Action? We identified six common drivers for acting on accessibility: (1) need to be compliant to standards (this category was often coded in conjunction with the following categories), (2) government agency and/or government funded, (3) public-facing products/services, (4) maturity, (5) lawsuits, and (6) individual advocates (see Table 6).

It was most common (18 interview sessions—31%) for participants to mention compliance (e.g., to Section 508 of the US Rehabilitation Act) and standards (e.g., Web Content Accessibility Guidelines) when asked about how accessibility was considered. For example, P32, an Experience Design Director at an agency, spoke of compliance in their response:

> "Our clients are massive companies, and their audience is in the billions. The beauty retailer that I have referenced has billions of consumers as well. You have to be very sensitive to the fact that when you're coming up with solutions, you have to not just understand accessibility in terms of the basics like AAA compliance, but you also have to understand accessibility in terms of diversity of representation through photography and through the copy that you use."

Working for the US government and/or receiving government funding was another common driver mentioned in 10 (17%) interview sessions. P21, a Senior Researcher at a consumer research organization, mentioned government funding when also discussing compliance to standards:

> "It is very much considered when we make recommendations, we do make sure that they're all 508 compliant. Because all of our government deliverables need to be compliant. But we don't necessarily mock up our recommendations, but when we do then we run it by our team here, we have a 508-compliance specialist who is on the design team that we're integrating more with."

In 9 (16%) interview sessions, participants discussed the need for accessible technology when a product was public-facing. P29, the Lead UX Architect at their consultancy organization, told us about how public-facing products affected accessibility considerations:

> "I've done some projects where I've been forced to really do that. I think I mentioned before, I did a lot of work with a water utility and because they're a public utility, they had to pay very close attention to that. They were under a regulatory body that forced them to be ADA compliant … so they had an outside auditor audit all of my wireframes and UX work. And they found a lot of stuff that wasn't compliant and not all of it I agreed with aesthetically, but like it made total sense."

Drivers to take actions towards accessibility was discussed in relationship to maturity in 5 (9%) interview sessions. For example, P27, a Design Director who worked at a digital consultancy, had a perspective that spanned many organizations:

Table 7. Reasons and Drivers of Non-action

Reasons and Drivers of Non-action	Number of Interview Sessions (out of 58)
Not in project scope	7
Pushback from other teams	7
Lack of resources	6
Not included in formal education	4
Considered part of future work	3

> "I would say mature accessibility from a technical perspective is actually acknowledging that there are ways of defining the code base that facilitates readers. On a more philosophical level, true accessibility is doing due diligence about what accessibility really means."

Lawsuits and fear of lawsuits was discussed in 4 (7%) interview sessions. P59, a Senior UX Researcher at a retail organization that was sued, spoke of how that was the motivating driver for considering accessibility:

> "Oh gosh. Uh, so we got sued. So accessibility is big . . . it happens to a lot of large companies. It's just a thing that happened a couple of years ago."

Finally, individual advocates were also mentioned in 4 (7%) interview sessions as the driving force behind accessibility considerations. P10, who worked as a UX Researcher at an educational organization, told us about how one designer really took to the role:

> "And we have one designer who's kind of in charge of accessibility standards. And she attends a lot of workshops and webinars and disseminates a lot of that information."

4.1.6 What were the Reasons Given for Non-action? Recall, among the 58 analyzed interview sessions, 14 (24%) of participants claimed that there were no actions taken at their organization (or by their clients) towards making products and services accessible. We identified five common drivers (often overlapping) for not acting on accessibility: (1) not in project scope, (2) push back from other teams, (3) lack of resources, (4) not included in formal education, and (5) future work, summarized in Table 7.

The most common two reasons given in 7 (12%) interview sessions each was that it was not in the project scope and that there was pushback from other teams. In an example coded for both, P53, a UX consultant, told us:

> "Like I said before, the urgent trumps the important, right. There's always something else that shoves it down on the list. I personally believe that organizations ignore this at their own peril. Even if your only interest is the bottom line, I still think you ignore this stuff at your peril. You're missing a massive chunk of what your audience could be."

Lack of resources, e.g., time and money, was mentioned in six (10%) interview sessions in which participants were not acting on accessibility. P47, a UX Principal at their company focused on retail, said:

> "It's just a matter of timeline. And this was a project that they were talking about even last year. And I said, 'A UX team of one can't do all this other work. Plus, I'm doing visual design, plus we are looking at all the different web properties . . .

Table 8. Cognitive Awareness

Cognitive Awareness	Number of Interview Sessions (out of 58)
Highly knowledgeable | Directly involved in actions	18
Knowledgeable | Actions taken but no involvement	17
Semi-knowledgeable | Actions taken but no involvement	12
Semi-knowledgeable | No actions taken	10
Not knowledgeable | No actions taken	1

> I can't… you have to tell me what we're going to cut.' Right? One of the things I'm actually looking for in the current batch of resumes is people that have a background [in accessibility]."

That accessibility was not included in formal education was discussed in 4 (7%) interview sessions as the main driver of non-action. P42, a UX Consultant who has taught in a Bootcamp program, responded:

> "That is a great question and I wish in education that we would talk more about that. I didn't do this in my courses years ago because it was not something that was considered…but I have found that more recently that accessibility is often taught as a nice thing if we have time to cover it. And it really needs to be baked in as a core."

Finally, in 3 (5%) of interview sessions, participants spoke about accessibility in terms of future work. When explaining why their company did not consider accessibility, P63, a Senior Manager of Product Design at an organization who created HR software, explained:

> "It's just not on the list for this year. So what we're doing…and what we can unilaterally control, is colors. We have complete control over what colors are in the product. We're doing the best we can for accessibility, but we know that there's more that we should be doing. That's just sitting in our professional backlog waiting to become important to the business."

4.2 Mental Processes

We organized the mental processes by two key questions: (1) what was their cognitive awareness, i.e., how knowledgeable did they speak about concrete actions focused on accessibility at their organization (or their clients' organization)? And (2) what was their emotional reaction (if apparent)?

4.2.1 What was their Cognitive Awareness? We created a five-point Likert scale of cognitive awareness and placed each of the 58 transcribed interviews on that scale, summarized in Table 8.

We coded 18 (31%) of interview sessions at the highest level of 5 when at least one participant in the interview session was both highly knowledgeable about accessibility and had been personally involved in driving accessibility at their current and/or past organization(s). For example, P29, a Lead UX Architect at a consultancy, responded to our query (how do you consider accessibility?) by discussing how they take responsibility for educating his clients and internal designers:

> "Frequently and often. It's a tricky one to communicate. Not just for clients, but often even internally with designers. Where you say, 'that button needs a text label to the left of it,' even though it's not the sexiest thing to do. And it's not enough to just make the logo go home. You need to write the word home. The metadata can

> be read and everything needs the proper tags. And we can't use icons that aren't idiomatic because people won't understand them if they have cognitive disabilities. Like I pay a lot of attention to that stuff and push it into whatever I do."

We coded 17 (29%) interview sessions at the level of 4. The participant(s) involved in these interview sessions were knowledgeable about accessibility considerations and were aware that their current organization (or client's) were taking concrete actions, but they themselves were not involved. Their answers included informed discussion about specifics such as citing compliance to Section 508 standards and user testing with people who had disabilities. This was commonly coded in interview sessions in which organizations had a dedicated team/specialists. For example, P16, a Senior Design Research Manager at a large ecommerce organization, told us:

> "Over the years, we have built up more of an accessibility team and group. Our team doesn't specifically do anything with accessibility anymore. We did, a couple of years ago. I actually did research with people who were blind, deaf, hard-of-hearing, and other physically disabled folks, which was fascinating, and I loved it and it was amazing work and very eye-opening. But we have more dedicated teams that focus on that now."

Twelve (21%) of the interview sessions were coded at the level of 3. As in category 4, interviewees related that action was being taken by their organization (or their clients) by someone else. But unlike category 4, when describing those considerations, they were vague about specifics such as citing standards. Again, this was common when there was a dedicated team/specialists. P24, a Director of Design at a financial services organization, said:

> "Accessibility is not necessarily at the forefront. Other teams do more of the testing and vetting for that. We have a standards and patterns team that provides the version of design systems that all the product teams are to utilize. They do a lot of the accessibility, vetting that it follows accessibility checks and guidelines. They get their best practices and guidelines from a central accessibility team we have here. . . .and they perform their own kind of evaluations and comments reviews across all the different governing bodies, all that kind of stuff, for things like guidelines."

We coded 10 (17%) interview sessions at the level of 2. Participants in these interview sessions expressed a similar level of accessibility knowledge as the previous category, but since there were no actions taken by their organization (or clients) there were no specifics to discuss. P26, a Head of User Experience at a telecommunications organization, responded:

> "Yeah, that is also something we are missing right now. We are catching up on this because this is... this has already become a big trend. For the accessibility functions, we need to invest a lot of resources . . . .maybe starting next year, we can have more resources."

Interviewer:
Do you have an idea of why accessibility is not a bigger priority within [your organization]?

> "I would say maybe they are not aware of social responsibility right now. Because definitely from the business side, they focus on sales"

Finally, we only coded one interview session at the level of 1. This category was reserved for when no actions were taken, and the participant did not convey any knowledge about

Table 9. Emotional Reactions

Cognitive Awareness	Number of Interview Sessions (out of 58)
Positive: Passionate and invested	14
Neutral: Explaining shortcomings	4
Negative: Shame/guilt	14
Negative: Frustration about lack of UX involvement	4

accessibility.The one participant, P31, who was a UX Lead at a healthcare company, suggested in vague terms that they wanted their company to consider it:

> "It's interesting you said that because I mentioned it the other day. And I think it's important. I talk about it, but if you said what are some major accessibility rules, I wouldn't be able to tell you. I'm not going to lie."

4.2.2 What was their Emotional Reaction (if Apparent)? We separated the emotional reactions to our questions into positive, neutral, and negative responses, summarized in Table 9.

4.2.2.1 Positive Responses. We coded 14 interview sessions for a positive response that we identified as reflecting investment in accessibility where participants expressed a high level of passion for the topic. Four of those 14 interview sessions were coded at a Likert level of 4 in their knowledge. In an example, P6, a Principal Content Strategist at an organization focused on cybersecurity, expressed investment this way:

> "It could be better. It could be much worse. It is the responsibility of that engineer…but we're all paying attention to this. We're all trying, like we're all thinking about it as something… we're thinking about the design system and as we build out components. It is something we're all invested in."

Unsurprisingly, most of the positive responses came from the remaining 10 interview sessions who were also coded in the highly knowledgeable level in the previous section. P14, a User Experience Architect and Adjunct Professor, who was one of six interviewees to bring up accessibility unprompted, told us a story about how they became passionate about accessibility:

> "There's some interesting history here. When I was at [company] we had a developer who had serious, serious pain and injury to his arm, and he couldn't do his job. So we worked on using voice input …[it was] very, very rudimentary in those days. We built a thing where he could slide rather than lift up and down with his hand. It was like the first accessibility study that anybody had done at one of the largest computer companies in the world at that point. So, I kind of got interested in that. So, along the way at every company I go to, I asked 'what are you doing?' I became the person most knowledgeable about accessibility, so I was asked to do the reviews for several companies."

4.2.2.2 Neutral Responses. We coded four interview sessions for a neutral response in which the participant(s) explained why there were shortcomings in how their organization addressed accessibility. P46, a User Experience Manager at a financial services organization, explained their company's lack of addressing accessibility because they are managing a legacy system:

> "We acknowledge the need for an accessibility strategy…."

Interviewer:
Are you public-facing in any way?

> "No .... this would be for people with disabilities who are working in this field. It's a conversation that I have barely started. From a technology standpoint, we would literally have to re-architect everything. It would be a massive, massive effort. There is some growing acknowledgement that we need to start looking into this. But that's not at the top of my list right now. We're trying to build in some of, at least the basic things into the design system. We started a design system when I got here."

4.2.2.3 Negative Responses. We identified two common categories of negative responses: (1) shame/guilt and (2) frustration about the lack of UX involvement.

We coded 14 interview sessions for when participants expressed a sentiment of shame and/or guilt about the lack of investment in accessibility. In all cases, participants acknowledged the need for accessibility but with a shameful affect to their responses. P53, a UX Consultant who we previously quoted as telling us the reason for non-action was that "the urgent trumps the important," responded when asked about accessibility considerations:

> "You're not gonna like my answer ... not nearly to the degree which it should. The unfortunate reality I think is that there isn't, for a lot of organizations, enough of a consequence for ignoring it. In my general experience with organizations of every kind is that in a lot of cases there are things that they won't address until it's really causing some particular pain. Whether that's personal pain, organizational pain, or bottom-line profit and loss pain. Aside from that cynical answer, I think the emphasis is becoming greater on accessibility on the part of the people who build these products. And what I do see a lot of is that people build in accessibility .... features that they consider when they design, they're thinking about all these things and they tackle the low-hanging fruit anyway without being asked, without it being part of some official mandate. And I think that's a very positive thing because I honestly think that's what it's going to take. It really is, at the end of the day, up to the individual people doing the work to make sure that this happens."

Finally, we coded four interview sessions for expressing frustration about the lack of UX involvement in accessibility considerations. P17, a Senior User Researcher who told us about how their company spent a lot of money on an "empathy lab," expressed a lot of frustration about how their organization was including UX:

> "It's usually someone else's job. It's usually legal... that makes me laugh. We're just trying to not get sued is the gist of what I see. In my opinion, that's pathetic. It's just wrong to just hover right above the bar. And even then, are they even above the bar? But why isn't it everyone's job? It always gets pushed aside, like even at [company]... if you naturally push someone to be faster, deliver faster, deliver cheaper, you're going to cut stuff. You start cutting accessibility, localization. Like you don't consider any of that 'cause you don't have time. I think generally if you ask every, every designer I've ever worked with, do they care about accessibility? Either they don't know how to incorporate it beyond color contrast or it is just an afterthought."

P17 elaborated on their frustrated response by discussing the lack of diversity, specifically related to people with disabilities, in computing professions:

> "Why are we not considering people with various ability levels in our hiring? I think our metrics of how we evaluate people is why people with accessibility needs

are often not even considered for our jobs. Why can I only think of one person that I immediately work with, with an accessibility need?"

5 DISCUSSION

We organized this section into five major takeaways with implications for UX practice and HCI/CS education: (1) the importance of design systems and coding, (2) considerations of more inclusionary practices, (3) the limitations of accessibility considerations and beneficiaries, (4) the limitations of *Who* is driving accessibility, and (5) the limitations of *What* is driving accessibility.

5.1 The Importance of Design Systems and Coding

The most discussed action in relation to accessibility was adoption and/or creation of design systems. Additionally, the use of design systems appeared to be a trend, as it was more common in the most recent round of interviews. The implication for industry is simple: If your organization is not yet moving towards adopting—or have already adopted—a design system, then your organization is behind and therefore not capitalizing on a design system's abilities to structurally embed accessibility in your products. The importance of design systems in accessibility was also somewhat supported in Liete et al. [39] in their recent study of mobile developers in Brazil. They found that 30% of the developers were aware of the standards outlined in Apples' UIKit for IOS and 27% were aware of Google's Material Design for Android; the authors suggested that while the design systems were not solely focused on accessibility, the accessibility guidelines provided in the design systems helped raise awareness.

To help industry practitioners, there is much guidance on how to create and/or adopt a design system. Industry information about design systems include books [26, 69, 74], blog postings through sources such as "Hey Designer" [21], and videos from practitioners recounting their experiences from sources such as Rethink [29]. There are also helpful repositories that can serve as examples [6] and many open-source design systems that practitioners can adopt such as Google's Material Design [28] and Orbit's Kiwi Design System [48].

While the academic conversation about design systems is under-represented among current papers in the ACM Digital library, there are some helpful resources. In recent examples, Churchill [20] argued for the efficacy of design systems in a 2019 *Interactions* article. In two articles that recounted first-person experiences with design systems, Moore et al. [45] presented a poster of their first-person account creating IBM's Alma Design System, and Edelberg and Kilrain [23] provided guidance on important considerations when approaching design systems. In a rare mention of accessibility in relation to design systems, Yew et al. [77] published an extended abstract in which they gathered opinions and perceptions about design systems through a survey from people attending Clarity (a design systems conference) in 2019. Their major findings included the importance of communication between engineering and design teams for implementing systems and including accessibility requirements. All these resources are very helpful in understanding what design systems are and expected to do for an organization, but do not provide guidance to instructors on how to integrate systems in HCI and CS programs.

In one example of instructor guidance for design students, Shin and Yeh [63] posted a YouTube presentation in May 2021 on how they incorporated "systems thinking" and design systems in two of their offerings at FIT, State University of New York: (1) an 8-week UI certificate program and (2) a 15-week BFA design program. While an informative presentation for design students, their programs were both relatively short, and accessibility considerations were not a major focus. The findings in this article encouraged us to make an explicit connection between design systems and accessibility for our own students. To that end, we are currently experimenting with ways to teach

design systems and have proposed a scalable model and report our student experiences in a recent paper [59].

The importance of the role of coding was also highly related to design systems and developers as the "doers" of accessibility. This finding also has two implications for HCI education. First, it is another call to embed accessibility when teaching web-based coding. Second, all practitioners working in UX—even those who consider themselves designers—should be encouraged to attain at least basic abilities in coding HTML, CSS, and SASS so they have an understanding of how the web-based components that they are likely to use in their professions are achieving accessibility.

5.2 Considerations of More Inclusionary Practices

A common action for considering accessibility was including people with disabilities in usability testing. If people with disabilities make up at least 25% of our population, then people with disabilities should comprise a similar number in recruitment for user studies. Industry options include working through companies like Knowbility [7] that have expertise practicing inclusionary usability studies and training programs such as WebAim [1] and Deque [5]. And while including people with disabilities in user studies is an obvious and often repeated recommendation, we argue that pedagogical discussion about balancing the learning of basic research methods (including usability) while also interacting with diverse populations has been under-emphasized. In other words, it is challenging—and has the potential to overload a single course—to teach both research methods and ethics, etiquette, and techniques for interacting with people who have disabilities. The obvious answer to this challenge is to teach research methods and usability as a pre-requisite for an accessibility course that requires conducting research with people who have disabilities. This is another challenge when considering which courses are required versus which are electives in HCI programs that need to cover a multitude of topics.

Among our interviewees, another somewhat common approach to considering accessibility was to have employees participating in training using simulation labs. Simulation labs have been criticized as ineffective in previous work [14, 33, 48], because a simulation does not accurately replicate the experience of a disability. Additionally, simulations aimed at people who do not have disabilities unintentionally suggest that people with disabilities cannot be designers [14]. Tigwell [69] presented findings in CHI 2021 from a survey conducted with 92 sighted designers and 17 people with visual impairments to explore their perceptions of simulation labs with the aim of addressing some of this critique. The sighted participants were largely unaware of the controversies around simulation labs, and the visually impaired participants offered many suggestions for better integrating people with disabilities throughout design and development.

While well intended, neither of these two common concrete actions are deeply inclusionary, because in usability studies people with disabilities are not considered until later in design, and in simulations labs they are not included at all. Considering these reasons, Oswal [49] identified an exclusionary boundary between UX and accessibility that he attributed to gaps in designer knowledge about people with disabilities. His recommendation was to turn to an **"accessibility user experience" (AUX)** model that directly engages people with disabilities in the design process in both participatory and critical ways. Similarly, Melonçon and Ranade's introduction to a special issue on accessibility [45] argued that accessibility approaches are too often tacked on at the end and not incorporated throughout the design process. They argued for inclusive accessibility, "a methodological framework that highlights simultaneously the beginning (inclusive and participatory audiences) and the end (usability)" (p. 216). We agree that an inclusive and accessible UX model is worth working towards, but we also recognize that these models are not yet feasible for many instructors, students, and UX practitioners.

This cited work and our findings join in the chorus of calls to increase the diversity of technology workers by encouraging the hiring of people who have disabilities, which echoes the sentiments of P17: "Why are we not considering people with various ability levels in our hiring?" In further support of inclusionary practice, P14's story of how they became an advocate was directly related to first-person experiences with a co-worker who was experiencing a disability. We echo that reflection and ask fellow educators: How can we actively recruit more students with disabilities? HCI and UX are fields that would benefit greatly from a more diverse student and faculty population; therefore, we urge academic researchers and program directors to develop strategies to actively recruit students and faculty who have disabilities.

5.3 The Limitations of Accessibility Considerations and Beneficiaries

While any action taken towards accessibility is good, the categories of action were somewhat superficial and largely focused on what was referred to as "low-hanging fruit" considerations such as color, color contrast, and larger text. Note that this was an echo of what we found in our industry interviews in 2012 [55]. Similarly, the beneficiaries of actions were mostly people with vision impairments. Perhaps this is expected, given that 70% of typical human input is through vision [25]; as such, it is the easiest impairment for people without visual impairments to imagine. However, the landscape of disabilities is vast. Even when just considering "blind," there is a large continuum that was not discussed or mentioned by participants, which left the impression they were mostly unaware of the scope and range of accessibility needs even within this one large category of disability. These findings emphasize the need to increase awareness in both industry and education on the spectrum of disabilities that affect how someone experiences and interacts with technology.

5.4 The Limitations of *Who* Is Driving Accessibility

The two groups most cited as responsible for achieving accessibility were dedicated teams/specialists and engineers/developers. Among our participants, only P14 considered themself a (self-taught) specialist and a majority (69%) were not directly involved with ensuring accessibility. Resting the responsibility for accessibility with those two groups may be effective strategies for organizations but could potentially also lead to an attitude of "that is someone else's problem" as an unintended consequence for UX professionals. This was implied in P6's assertion that accessibility considerations: *"It could be better. It could be much worse. It is the responsibility of that engineer,*" and in P6's frustrated comment: "*It's usually someone else's job.*" Additionally, our 18 (31%) participants who were directly involved in assuring accessibility were much more likely to have a positive affect when asked about accessibility. Together, these findings implied that organizationally separating UX-ers from accessibility procedures can potentially lead to undesirable outcomes such as a disconnect from the process or, at worst, an abdication of responsibility for ensuring the products they design are accessible to all.

Additionally, participants who responded negatively with guilt, shame, and/or frustration were not highly involved in assuring accessibility. We felt that their negative reactions were related to their awareness that accessibility should be prioritized while acknowledging that it currently is not. There were no participants in the study who dismissed the importance of accessibility. Here, we see an opportunity for UX practitioners to take more of a leading role in advocating for accessibility within their organizations. However, to be able to influence practice, UX professionals may need more to expand both technical and rhetorical skills in this area.

5.5 The Limitations of *What* Drives Accessibility

The common drivers of accessibility were more often associated with compliance than an ethical commitment to designing for people with disabilities. Government funding, public-facing

products, and fear of lawsuits were all commonly cited among our participants. This finding indicated that holding organizations' responsibility through top-down methods were somewhat effective, indicating a need for rigorous regulation. An alternative to top-down methods as a driver is the bottom-up approach from individual advocates.

Previous work found that individual advocates were the leading driving force bringing accessibility into academic programs [16, 52]. However, this did not generalize to our industry interviewees. Because we believe that the individual advocate model is not particularly scalable, we felt this was a positive finding. Related to top-down approaches, several participants connected strong accessibility practices to a high level of organizational maturity.

UX maturity is often used to describe how well integrated UX is within an organization. There are multiple models of UX maturity. For example, Pernice et al. [51] of the Nielson-Norman Group describe a spectrum of six levels of maturity from "absent – level 1" to "user-driven – level 6." The higher maturity level, the more UX is embedded into the organization's practice and culture. Relatedly, several authors have articulated models of accessibility maturity. In one recent example, Sapega [61] introduced a five-level model from "initial – level 1" to "optimizing – level 5." In academic work, Quintal and Macias [56] introduced a maturity model that included accessibility. While we did not research the efficacy of maturity models in industry, many argue that they can be helpful for organizations to self-reflect on how well they are achieving goals and drive improvement towards those goals. Additionally, we felt that maturity models focused on accessibility may be helpful frameworks for HCI and UX students, as they learn about the scope of accessibility considerations and equip them with tools to assess and argue for action in their future organizations.

Most of the common reasons given for not acting on accessibility concerns included accessibility being out of project scope, pushback from other teams, lack of resources, and being part of future work. These are common reasons and again point to the fact that many organizations and teams have not prioritized accessibility. However, more germane for instructors and educators was the data highlighting that practitioners did not receive formal education in accessibility. This finding echoes previous research by Azinkot et al. [12] and Patel et al. [50]. In our ruminations, we also reflected on Bohman's dissertation [16], recalling that two of the programs he studied in 2012 were focused on educating accessibility specialists, but that neither program survived the two years of the project due to lack of enrollment. We wondered if perhaps those programs were ahead of their time. Given the disconnect between industry's desire for more accessibility expertise and the lack of inclusion in HCI and CS programs, educators might consider specialist programs or creating accessibility specialist tracks/minors as part of their degree programs or better integrating or centering accessibility as a focus in HCI or UX programs, similar to Sonka et al. [74]. A last key takeaway from this research is that industry and educators should work together to clearly communicate to students about the opportunities available to those with accessibility expertise, i.e., accessibility expertise will strengthen a student's employability opportunities. We also encourage partnerships with industry to foster students' study of accessibility in practice.

6 LIMITATIONS AND FUTURE WORK

Our protocol was not designed to explore design systems, leaving many unanswered questions on successful (or not) execution strategies. Future work will include how design systems are created, managed, and communicated across teams. Future work will also include further exploration and assessment of techniques for teaching about design systems as a strategy for addressing accessibility. We are also interested in exploring the efficacy of industry training programs such as those offered by WebAim and Deque to inform our pedagogy. Last, we hope to find collaborators who are educators in non-US-based higher education settings to expand this work beyond the current US focus.

7 CONCLUSIONS

In this article, we presented our findings from 58 interview sessions involving 65 senior UX professionals when asked "How do you consider accessibility in your work?" We analyzed the question using a framework borrowed from critical discourse analysis focusing on material processes (actions and non-actions) and mental processes (cognitive awareness and emotional responses). Most participants (76%) had some knowledge of accessibility actions taken at their organizations. Design systems were the most frequently cited strategy to address accessibility. The primary drivers of accessibility were compliance to top-down imposed standards. Commonly, UX teams relied on others, e.g., dedicated teams/specialists, however, participants who were actively engaged and knowledgeable about accessibility were more likely to have a positive affect when asked the question. The cited categories of consideration were somewhat superficial and largely focused on vision-related challenges. This work also supported previous work that many felt their formal education did not prepare them appropriately for accessibility considerations. While our findings have several implications for education and industry, the key takeaway was the importance of design systems as a strategy for addressing accessibility and that educators need to include design systems in HCI and CS programs.

ACKNOWLEDGMENTS

We wish to thank our participants for sharing their valuable time and expertise.

REFERENCES

[1] Accessibility Training. Retrieved January 2, 2022 from https://webaim.org/services/training/.
[2] Accessible Technology Skills Gap Report. Retrieved January 2, 2022 from https://www.peatworks.org/accessible-technology-skills-gap-report/.
[3] Americans with Disabilities Act. Retrieved January 2, 2022 from https://www.dol.gov/general/topic/disability/ada.
[4] Bootstrap. Retrieved January 2, 2022 from https://getbootstrap.com/.
[5] Deque University. Retrieved January 2, 2022 from https://dequeuniversity.com/.
[6] Design Systems Repo: A frequently updated collection of Design System examples, articles, tools and talks. Retrieved January 2, 2022 from https://designsystemsrepo.com/.
[7] Knowbility. Retrieved January 2, 2022 from at https://knowbility.org/.
[8] Survey of Web Accessibility Practitioners #2 Results. Retrieved January 2, 2022 from https://webaim.org/projects/practitionersurvey2/.
[9] Teach Access. Retrieved January 2, 2022 from at https://teachaccess.org/.
[10] The WebAIM Million: An annual accessibility analysis of the top 1,000,000 home pages. Retrieved January 2, 2022 from https://webaim.org/projects/million/.
[11] Disabled Americans are less likely to use technology. Retrieved January 2, 2022 from https://www.pewresearch.org/fact-tank/2017/04/07/disabled-americans-are-less-likely-to-use-technology/.
[12] Shiri Azenkot, Margot J. Hanley, and Catherine M. Baker. 2021. How accessibility practitioners promote the creation of accessible products in large companies. In *Proc. ACM Hum.-comput. Interact.* 5, CSCW 1 (Apr. 2021). DOI: https://doi.org/10.1145/3449222
[13] Deborah Bach. 2018. How gamers with disabilities helped design the new Xbox adaptive controllers elegantly accessible packaging. *Microsoft | Stories*. Retrieved from https://news.microsoft.com/features/how-gamers-with-disabilities-helped-design-the-new-xbox-adaptive-controllers-elegantly-accessible-packaging/.
[14] Cynthia L. Bennett and Daniela K. Rosner. 2019. The promise of empathy: Design, disability, and knowing the "Other." In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI'19)*. Association for Computing Machinery, New York, NY, 291–213. DOI: https://doi.org/10.1145/3290605.3300528
[15] Tingting Bi, Xin Xia, David Lo, John Grundy, Thomas Zimmermann, and Denae Ford. 2022. Accessibility in software practice: A practitioner's perspective. *ACM Trans. Softw. Eng. Methodol.* 31, 4 (October 2022). DOI: https://doi- 10.1145/3503508
[16] Paul Ryan Bohman. 2012. *Teaching accessibility and Design-For-All in the Information and Communication Technology Curriculum: Three Case Studies of Universities in the United States, England, and Austria.* Dissertation, Utah State University.

[17] Anders Bruun, Marta Kristin Larusdottir, Lene Nielsen, Peter Axel Nielsen, and John Stouby Persson. 2018. The role of UX professionals in agile development: A case study from industry. In *Proceedings of the 10th Nordic Conference on Human-Computer Interaction (NordiCHI '18)*. Association for Computing Machinery, New York, NY, 352–363. DOI: https://doi.org/10.1145/3240167.3240213

[18] Alex Carmichael, Alan F. Newel, and Maggie Morgan. 2007. The efficacy of narrative video for raising awareness in ICT designers about older users' requirements. *Interact. Comput* 17 (2007), 587–596.

[19] Disability Impacts All of Us. Retrieved from https://www.cdc.gov/ncbddd/disabilityandhealth/infographic-disability-impacts-all.html.

[20] Elizabeth F. Churchill. 2019. Scaling UX with design systems. *Interactions* (Sept.–Oct. 2019), 22–23. DOI: https://doi-org./10.1145/3352681

[21] Andy Clarke. 2021. Design Systems Don't Kill Creativity but That Wasn't the Question. *Hey Designer*. Retrieved from https://stuffandnonsense.co.uk/blog/design-systems-dont-kill-creativity-but-that-wasnt-the-question?ref=heydesigner.

[22] How Many of Your Users Need Accessible Websites? Retrieved from https://www.sitepoint.com/how-many-users-need-accessible-websites/.

[23] Jenya Edelberg and Joseph Kilrain. 2020. Design systems: Consistency, efficiency & collaboration in creating digital products. In *Proceedings of the 38th ACM International Conference on Design of Communication (SIGDOC'20)*. Association for Computing Machinery, New York, NY, 1–3. DOI: https://doi.org/10.1145/3380851.3416743

[24] Yasmine N. El-Glaly. 2020. Teaching accessibility to software engineering students. In *Proceedings of the 51st ACM Technical Symposium on Computer Science Education (SIGCSE'20)*. Association for Computing Machinery, New York, NY, 121–127. DOI: https://doi.org/10.1145/3328778.3366914

[25] Stephen Few. 2021. *Now You See It: An Introduction to Visual Data Sensemaking*. Analytics Press, El Dorado Hills, CA.

[26] Brad Frost. 2016. Atomic Design. Retrieved from https://shop.bradfrost.com/.

[27] Paula Gabbert. 2020. Teaching accessibility in a CS0 class. *J. Comput. Sci., Coll.* 35, 7 (Apr. 2020), 11–20.

[28] Material Design. Retrieved from https://material.io/design/introduction.

[29] Hazel Jennings. 2019. How your design system can define and raise the quality bar for your product. *Rethink City* (2019).

[30] Megan Jones. 2021. Web Accessibility: What is it and why is it important?. *Gravity*. Retrieved from https://www.gravityforms.com/web-accessibility/.

[31] Jin Kang, Chantal M. J. Trudel, Audrey Girouard, and Adrian D. C. Chan. 2021. Research and education in accessibility, design, and innovation (READi) training program: Preparing graduate students for careers in accessibility research and design. In *Proceedings of the 3rd Annual Symposium on HCI Education (EduCHI)*. Retrieved from https://educhi2021.hcilivingcurriculum.org/wp-content/uploads/2021/04/educhi2021-final54.pdf.

[32] Saba Kawas, Laura Vonessen, and Andrew J. Ko. 2019. Teaching accessibility: A design exploration of faculty professional development at scale. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education (SIGCSE'19)*. Association for Computing Machinery, New York, NY, 983–989. DOI: https://doi.org/10.1145/3287324.3287399

[33] Claire Kearney-Volpe, Devorah Kletenik, Kate Sonka, Deborah Sturm, and Amy Hurst. 2019. Evaluating instructor strategy and student learning through digital accessibility course enhancements. In *Proceedings of the 21st International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS'19)*. Association for Computing Machinery, New York, NY, 377–388. DOI: https://doi.org/10.1145/3308561.3353795

[34] Brian Kelly and Yasmine El-Glaly. 2021. Introducing accessibility to high school students. In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*. 163–169. DOI: https://doi.org/10.1145/3408877.3432466

[35] Sri Kurniawan, Sonia Arteaga, and Robert Manduchi. 2010. A general education course on Universal access, disability, technology and society. In *Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS'10)*. Association for Computing Machinery, New York, NY, 11–18. DOI: https://doi.org 10.1145/1878803.1878808

[36] Richard E. Ladner and Matt May. 2017. Teaching accessibility. In *Proceedings of the ACM SIGCSE Technical Symposium on Computer Science Education (SIGCSE'17)*. Association for Computing Machinery, New York, NY, 691–692. DOI: https://doi.org/10.1145/3017680.3017804

[37] Jonathan Lazar. 2011. Using community-based service projects to enhance undergraduate HCI education: 10 years of experience. In *Proceedings of the InCHI'11 Extended Abstracts on Human Factors in Computing Systems (CHIEA'11)*. Association for Computing Machinery, New York, NY, 581–588. DOI: https://doi.org/10.1145/1979742.1979653

[38] Jonathan Lazar, Alfreda Dudley-Sponaugle, and Kisha-Dawn Greenidge. 2004. Improving web accessibility: A study of webmaster perceptions. *Comput. Hum. Behav.* 20 (2004), 269–288.

[39] Manoel Victor Rodrigues Leite, Lilian Passos Scatalon, Andre Pimenta Freire, and Marcelo Mederos Eler. 2021. Accessibility in the mobile development industry in Brazil: Awareness, knowledge, adoption, motivations and barriers. *J. Syst. Softw.* 177 (2021). Retrieved from 10.1016/j.jss.2021.110942

[40] Stephani Ludi. 2007. Introducing accessibility requirements through external stakeholder utilization in an undergraduate requirements engineering course. In *Proceedings of the IEEE Computer Society 29th International Conference on Software Engineering*. 736–743.

[41] Craig M. MacDonald, Emma J. Rose, and Cynthia Putnam. 2022. How, Why and with Whom Do User Experience (UX) Practitioners communicate? Implications for HCI education. *Int. J. Hum.-Comput. Interact.* DOI: https://doi.org/10.1080/10447318.2021.2002050

[42] David Machin and Andrea Mayr. 2012. *How to do Critical Discourse Analysis*. Sage, London, UK.

[43] Israel Martin-Escalona, Francisco Barcelo-Arroyo, and Enrica Zola. 2013. The introduction of a topic on accessibility in several engineering degrees. In *Proceedings of the IEEE Global Engineering Education Conference (EDUCON'13)*. 656–663.

[44] Lisa Meloncon and Nupoor Ranade. 2021. Introduction to special issue on accessibility. *IEEE Trans. Profess. Commun.* 64, 3, (Sept. 2021), 215–2220. DOI: https://doi.org/10.1109/TPC.2021.3090598

[45] Robert J. Moore, Eric Young Liu, Saurabh Mishra, and Guang-Jie Ren. 2020. Design systems for conversational UX. In *Proceedings of the 2nd Conference on Conversational User Interfaces (CUI'20)*. Association for Computing Machinery, New York, NY, 41–44. DOI: https://doi.org/10.1145/3405755.3406150

[46] Karine Nahon, Izak Benbasat, and Camille Grange. 2012. The missing link: Intention to produce online content accessible to people with disabilities by non-professionals. In *Proceedings of the 45th Hawaii International Conference on System Sciences*. 1747–1757, DOI: 10.1109/HICSS.2012.578

[47] Michelle R. Nario-Redmond, Dobromir Gospodinov, and Angela Cobb. 2017. Crip for a day: The unintended negative consequences of disability simulations. *Rehab. Psychol.* 62, 3 (2017), 324–333. DOI: https://doi.org/10.1037/rep0000127

[48] Orbit Kiwi Design System. Retrieved from https://orbit.kiwi/.

[49] Sushil K. Oswal. 2019. Breaking the exclusionary boundary between user experience and access: Steps toward making UX inclusive of users with disabilities. In *Proceedings of the 37th ACM International Conference on the Design of Communication (SIGDOC'19)*. Association for Computing Machinery, New York, NY, 1–8. DOI: https://doi.org/10.1145/3328020.3353957

[50] Rohan Patel, Pedro Breton, Catherine M. Baker, Yasmine N. El-Glaly, and Kristen Shinohara. 2020. Why software is not accessible: Technology professionals' perspectives and challenges. In *Proceedings of the Extended Abstract in the CHI Conference on Human Factors in Computing Systems (CHI EA'20)*. Association for Computing Machinery, New York, NY, 1–9. DOI: https://doi.org/10.1145/3334480.3383103

[51] Kara Pernice, Sarah Gibbons, Kate Moran, and Kathryn Whitenton. 2021. The 6 Levels of UX Maturity. *Nielsen Norman Group*. Retrieved from https://www.nngroup.com/articles/ux-maturity-model/.

[52] Cynthia Putnam, Maria Dahman, Emma Rose, Jinghui Cheng, and Glenn Bradford. 2016. Best practices for teaching accessibility in universities of classrooms: Cultivating awareness, understanding and appreciation for diverse user. *ACM Trans. Access. Comput.* 8, 4 (May 2016). DOI: https://doi.org/10.1145/2831424

[53] Cynthia Putnam and Beth Kolko. 2012. HCI professions: Differences and definitions. In *Proceedings of the Annual Conference on Extended Abstracts on Human Factors in Computing Systems (CHI EA'12)*. Association for Computing Machinery, New York, NY, 2021–2026. DOI: https://doi.org /10.1145/2212776.2223746

[54] Cynthia Putnam, Anuradha Rana, and Christina Hanschke. 2019. Efficacy of film for raising awareness of diverse users. In *Proceedings of the Annual Conference on Extended Abstracts on Human Factors in Computing Systems (CHI'19)*. Association for Computing Machinery, New York, NY, 1–6. DOI: https://doi.org/10.1145/3290607.3312992

[55] Cynthia Putnam, Katherine Wozniak, Mary Jo Zefeldt, Jinghui Cheng, Morgan Caputo, and Carl Duffield. 2012. How do professionals who create computing technologies consider accessibility? In *Proceedings of the 14th Annual ACM Conference on Conference on Computers and Accessibility (ASSETS'12)*. Association for Computing Machinery. New York, NY, 87–94. DOI: https://doi.org/10.1145/2384916.2384932

[56] Clara Quintal and José A. Macias. 2018. A capability maturity proposal for usability and accessibility centered processes. In *Proceedings of the International Conference on Human Computer Interaction (Interacción'18)*. Association for Computing Machinery, New York, NY, 11–18. DOI: https://doi.org/10.1145/3233824.3233836

[57] Sushant Ranjan. 2020. Accessibility is good for Business. *SAP | Community*. Retrieved from https://blogs.sap.com/2020/02/23/accessibility-is-good-for-business/.

[58] Emma J. Rose, Cynthia Putnam, and Craig M. MacDonald. 2020. Preparing future UX professionals: Human skills, technical skills, and dispositions. In *Proceedings of the 38th ACM International Conference on Design of Communication (SIGDOC'20)*. Association for Computing Machinery, New York, NY, 1–8. DOI: https://doi.org/10.1145/3380851.3416774

[59] Emma J. Rose, Cynthia Putnam, and Craig M. MacDonald. 2022. Teaching design systems: Toward a flexible and scalable model for the UX classroom. In *Proceedings of the 40th ACM International Conference on Design Communication (SIGDOC'22)*, Association for Computing Machinery, New York, NY. DOI: https://doi.org/10.1145/3513130.3558985

[60] Johnny Saldana. 2015. *The Coding Manual for Qualitative Researchers* SAGE Publications Ltd, Thousand Oaks, CA.
[61] Marissa Sapega. 2020. The Accessibility Maturity Lifecycle. *TGBir*. Retrieved from https://www.tpgi.com/the-accessibility-maturity-lifecycle/.
[62] Julie Schiller and Omid Farivar. 2017. How does automatic alt text work on Facebook? *Facebook Research*. Retrieved from https://www.facebook.com/help/216219865403298.
[63] Christie Shin and C. J. Yeh. 2021. In the file: Teaching systems thinking in the design classroom. *YouTube*. Retrieved from https://www.youtube.com/watch?v=hchsluJyw1A&t=2023s.
[64] Kristen Shinohara, Nayeri Jacobo, Wanda Pratt, and Jacob O. Wobbrock. 2020. Design for social accessibility method cards: Engaging users and reflecting on social scenarios for accessible design. *ACM Trans. Access. Comput.* 12, 4 (2020). DOI: https://doi-org/10.1145/3369903
[65] Kristen Shinohara, Saba Kawas, Amy J. Ko and Richard E. Ladner. 2018. Who teaches accessibility? A survey of U.S. computing faculty. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education (SIGCSE'18)*. Association for Computing Machinery, New York, NY, 197–202. DOI: https://doi.org./10.1145/3159450.3159484
[66] Sharon Snider, Willie L. Scott II, and Shari Trewin. 2020. Accessibility information needs in the enterprise. *ACM Trans. Access. Comput.* 12, 4 (2020). DOI: https://doi.org/10.1145/3368620
[67] Kate Sonka, Casey McArdle, and Liza Potts. 2021. Finding a teaching A11y: Designing an accessibility-centered pedagogy. *IEEE Trans. Profess. Commun.* 64, 3 (2021), 264–274. DOI: https://doi.org/10.1109/TPC.2021.3091190
[68] Tami Ternes. 2021. Amazon show and tell: EYE like this! *Assistive Technology*. Retrieved from https://ndassistive.org/blog/amazon-show-and-tell-eye-like-this/.
[69] Garreth W. Tigwell. 2021. Nuanced perspectives toward disability simulations from digital designers, blind, low vision, and color blind people. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI'21)*. Association for Computing Machinery, New York, NY, 371–315. DOI: https://doi.org/10.1145/3411764.3445620
[70] Shari Trewin, Brian Cragun, Cal Swart, Jonathan Brezin, and John Richards. 2010. Accessibility challenges and tool features: An IBM Web developer perspective. In *Proceedings of the International Cross Disciplinary Conference on Web Accessibility (W4A)*. 1–10. DOI: https//:doi.org/10.1145/1805986.1806029
[71] Eric M. Velleman, Inge Nahuis, and Thea van der Geest. 2017. Factors explaining adoption and implementation processes for web accessibility standards within eGovernment systems and organizations. *Univ. Access Inf. Soc.* 16 (2017), 173–190. DOI: https://doi.org/10.1007/s10209-015-0449-5
[72] Sarrah Vesselov and Taurie Davis. 2019. *Building Design Systems: Unify User Experiences through a Shared Design Language*. Apress, New York, NY.
[73] Annalu Waller, Vicki L. Hanson and David Sloan. 2009. Including accessibility within and beyond undergraduate computing courses. In *Proceedings of the 11th International ACM SIGACCESS Conference on Computers and Accessibility (Assets'09)*. Association for Computing Machinery, New York, NY, 155–162. DOI: https://doi.org/10.1145/1639642.1639670
[74] Kendra Walther and Kate Sonka. 2020. A study away summer program addressing accessibility. In *Proceedings of the 51st ACM Technical Symposium on Computer Science Education (SIGCSE'20)*. 1411. DOI: https://doi.org/10.1145/3328778.3372569
[75] Huan Wang, Lei Zhao, and Jianhua Jiang. 2017. A transitivity analysis of on-line product descriptions—A case study of book product descriptions. In *Proceedings of the International Conference on Business and Information Management (ICBIM'17)*. Association for Computing Machinery, New York, NY, 73–77. DOI: https://doi.org/10.1145/3134271.3134285
[76] Alex Xu. 2020. *System Design Interview – An Insider's Guide*. Byte Code LLC.
[77] Jude Yew, Gregorio Convertino, Abla Hamilton, and Elizabeth Churchill. 2020. Design systems: A community case study. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA'20)*. Association for Computing Machinery, New York, NY, 1–8. DOI: https://doi.org/10.1145/3334480.3375204
[78] Qiwen Zhao, Vaishnavi Mand, Paula Conn, Sedeeq Al-khazraji, Kristen Shinohara, Stephanie Ludi, and Matt Huenerfauth. 2020. Comparison of methods for teaching accessibility in university computing courses. In *Proceedings of the 22nd International ACM SIGACCESSS Conference on Computers and Accessibility*. Association for Computing Machinery, New York, NY, 1–12. DOI: https://doi.org/10.1145/3373625.3417013

Received 3 January 2022; revised 27 September 2022; accepted 8 November 2022