

How Accessibility Practitioners Promote the Creation of Accessible Products in Large Companies

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Although some technology companies have made significant strides towards the accessibility of their products, most consumer-facing technology products still pose access barriers to people with disabilities. Prior research has established that accessibility expertise is limited to a small number of practitioners in companies, but we do not know how these practitioners can affect change across a large organization. We sought to address this gap and understand how large companies that produce consumer-facing technologies integrate accessibility into their product lifecycle. We conducted semi-structured interviews with 30 accessible technology practitioners working at 13 companies. We found accessibility expertise was centered in three main roles within the company: on a central accessibility team, in champions, and in accessibility teams embedded into large product teams. Much of the work of these practitioners centered around education and development of tools and resources to allow designers and developers throughout the organization to implement accessibility. Our study revealed current practices for embedding accessibility in large companies, highlighting the gap between accessibility research and practice. We conclude by presenting areas that need future research to understand how to better support accessibility practice.

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

KEYWORDS:

Accessibility, design practice, translational science gap.

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1 INTRODUCTION

According to the US Census Bureau, nearly 40 million Americans had a disability in 2015, representing 12.6% of the US population [3]. People with disabilities have faced severe barriers in accessing physical and digital infrastructure, as well as consumer products. In the last decade, however, we have seen examples of technology companies significantly improving the accessibility of their products in innovative ways, receiving praise from advocacy organizations. For example, in 2009, Apple released VoiceOver, the first screen reader for touch screen devices

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[38]. More recently, Facebook released Automatic Alt Text, which automatically generated descriptions of photos to make them accessible to blind Facebook users [37,39].

This increased attention to accessibility in industry may have been related to increased regulations and resources. In 1998, the United States Congress amended the Rehabilitations Act of 1973, requiring federal agencies to make their electronic and information technologies accessible to people with disabilities. Most famously, Section 508 of this law states that “agencies must give disabled employees and members of the public access to information comparable to the access available to others” [40]. Following this legislation, organizations of experts and advocates developed accessibility guidelines and standards. Most notably, the Web Content Accessibility Guidelines (WCAG), developed by the Web Accessibility Initiative of the World Wide Web Consortium (W3C), was initially released in 1999, and was recognized by the ISO as an international standard in 2012 [41]. Regulations provided incentive and the guidelines provided a resource that companies could use to assess the accessibility of their products.

However, despite these regulations, resources, and prominent examples of accessibility-done-right, most commercial products today still do not accommodate the needs of people with disabilities. As one example, the WebAIM project found that at least 97.8% of the top one million homepages had accessibility problems [42]. Beyond the web, Ross et al. found that 100% of 100 popular mobile applications had at least one accessibility problem, and 72% had 5 or 6 accessibility problems [27]. These snapshots demonstrate that, in spite of legislation and the available resources, commercial consumer technologies still pose significant access challenges to people with disabilities.

In light of these accessibility successes and gaps, researchers must understand the daily practice of accessibility practitioners that impact the level of accessibility of consumer products, including their actions, decisions, and processes. This will allow us to better support accessibility practitioners, which could, in turn, enhance the accessibility of products. Some researchers have investigated this question over the past 20 years, identifying organizational factors that facilitate and hinder the practice of accessible design of products (e.g., [8,17,20,35,36]). They found that executive and managerial support was important, as well as an overall culture of social responsibility. In terms of organizational structure, they found that accessibility was typically driven by a small number of accessibility experts. Typical designers, developers, and quality assurance (QA) engineers did not have the knowledge or training to make websites or other technology products accessible. The accessibility expertise was held by a small team in larger companies, or in single practitioners, referred to as “champions,” in smaller companies, who had to disseminate their expertise across the different teams in an organization to ensure accessible design.

Large technology companies like Facebook, Google, and Apple have hundreds if not thousands of teams who work on a variety of products or product features. In order for these products to be accessible, the accessibility features must be considered across the design, development, and evaluation of these products; executives need to support it, developers need to implement it, and QA engineers need to test for it. This multifaceted implementation is critical, yet, at present, we do not know how companies are transferring such knowledge and skills from their accessibility experts across their organizations.

We aimed to address this gap and determine how accessibility practitioners promote accessibility within their organization to create and maintain accessible design. What tools and techniques do they use? What kind of knowledge do they transfer and to whom? In what settings and with what resources?

To answer these questions, we conducted an interview study with 30 accessibility experts who worked in 13 companies (the number of experts per company varied). We narrowed our scope to large, for-profit technology companies and recruited accessibility practitioners, individuals who worked on accessibility in their current role. We asked participants about their role and responsibilities, their team's composition and responsibilities, and how they interact with other teams and individuals within the organization. For context, we also asked about the participant's and their company's perception and support for accessibility.

We found that accessibility practitioners held one of three roles in their companies: they were part of a central accessibility team, championed accessibility in addition to their primary role as a designer or developer, or served as part of an accessibility team embedded within a large product team. Within each role, they promoted accessibility primarily by serving as educators of their co-workers. First and foremost, they taught others about general issues related to disability and awareness. Second, they prepared resources and tools to guide implementation. The flexibility they had in their roles allowed them to educate other employees through different channels, including new-hire training sessions, office hours, workshops, and company tools and guidelines.

In summary, we contribute findings from a study that showcase the different techniques used by accessibility practitioners in large companies to promote the creation of accessible products. Our findings shed light on current practices and highlight the gap between accessibility research and practice. To bridge this gap, we identify future research directions in accessibility research that will help facilitate the accessibility of products produced by organizations of all sizes.

2 RELATED WORK

2.1 Understanding Design Practice

Within the broader context of the human-computer interaction (HCI) field, researchers have been studying the practice of design. In 2008, Stolterman [31] advocated for a deeper exploration of design practice: interaction designers' daily motivations, activities, processes, and judgments. He argues that, "In order to change design practice, we need more research that examines, uncovers, analyzes, and interprets what interaction designers are already doing." To gain this deeper understanding, researchers have conducted surveys and interviews of practitioners, professionals in the user experience fields such as designers, user experience researchers, UI designers, etc. Overall, their findings revealed that practitioners found human-computer interaction theory mostly irrelevant, and that academic publications did not take into account the complexities of their roles; instead of relying on academic resources, practitioners mainly relied on their experience and intuition.

Clemmenson and Leisner [5] and Rogers [26] surveyed design practitioners to understand their use and knowledge of HCI theory. Clemmenson and Leisner surveyed 120 Danish practitioners and found that over 50% used at least one theory in their daily practice. In contrast, Rogers, who surveyed 34 practitioners in the US and UK, found that much fewer used theory, and most (85%) relied on their intuition and experience. Related to our work here, 5% of Rogers' respondents said they used guidelines, but it is unknown whether these were accessibility guidelines. More recently, Colusso et al. [6] interviewed 22 design practitioners about their use of resources in general, including academic theories and publications. They list resources used in four distinct design activities: understanding, brainstorming, building, and advocacy. Resources included design

examples, images found via web search, forums, and academic resources. Echoing prior findings, their participants felt that “academics did not care about implementation details such as contentious stakeholder situations or making design decisions on top of legacy structures.”

Beyond the use of resources, Goodman et al. [11] and Roedl and Stolterman [25] discussed the gap between the daily practice of designers and HCI research that aims to support them. Goodman et al. [11] reviewed HCI literature on design practice and conducted their own in-situ observations of designers at three companies. They propose future research questions and approaches to studying design practice, including reported accounts of practice, which we employ in this paper. In subsequent work, Roedl and Stolterman [25] focused their inquiry on the CHI conference in particular. They reviewed papers from the 2011 conference and interviewed 13 design practitioners. Consistent with other findings, they claimed that researchers’ view of design practice was too simplistic: there was a lack of consideration for resource constraints, negotiation with stakeholders, and collaboration activities.

The gap between research and practice, also referred to as the “translational science gap,” is not unique to HCI. As Colusso et al. [7] highlighted in their literature review, the translational science gap has been studied in a variety of fields including psychology and nursing. Gray et al. [12] proposed a model that captures this gap, with a “trickle down” transfer of knowledge from researchers to practitioners and a “bubble up” transfer from practitioners to researchers. Colusso et al. [7] augment this model by proposing three steps: basic research, applied research, and design practice.

The research discussed in this section has argued for the need to better understand design practitioners to improve the impact of HCI research; and the studies have uncovered the experiences of interaction designers and related practitioners. This begs the question: do accessibility practitioners have similar experiences as the design practitioners studied? Do they have the same motivations, actions, and judgments? Do they grapple with the same “design complexity” [31] in their daily work? In the following sections, we review related research that elucidates *accessibility practice*. As we discuss, they reveal that, distinct from design practitioners, a critical part of their work is to disseminate information about accessibility across their organizations. In this paper we study the ways in which this dissemination occurs, deriving new directions for research that will better support accessibility practice in particular.

2.2 Organizational Factors that Impact Accessible Product Design

Several scholars have investigated the barriers and facilitators involved in producing accessible products [8,17,20,22,35,36]. Through the lenses of Universal Design (UD) or Inclusive Design (ID), they aimed to understand what organizational factors lead to products that consider the needs of people with disabilities.

In a short but seminal paper, Vanderheiden and Tobias presented findings from an interview study with professionals at 22 companies from various industries. They compiled a set of barriers and facilitators to the practice of universal design [35]. They identified key barriers and facilitators, as well as some organizational practices that led to success. For example, large companies that had successfully implemented universal design tended to have a centralized team in charge of the process while smaller companies had UD “champions,” who informally promoted UD practices within their organization. Facilitators included executive support and sensitivity to regulation. In a follow-up paper [36], which included analysis from additional interviews and corroborating surveys, the authors focused on external factors impacting adoption of UD; they concluded that the most effective external factors were education and

government regulation. Within an organization, they argued, there was usually not enough expertise about UD to train others, so this training must come from other sources.

Following Vanderheiden and Tobias [35,36], Dong et al. [8] surveyed managers in companies in the United Kingdom from a variety of sectors to understand the barriers and motivators for practicing inclusive design. They hypothesized that different types of companies—consumer product manufacturers, retailers, and design consultancies—held different perceptions of these barriers and motivators. From their survey of 42 companies, they confirmed their hypothesis, finding that, interestingly, each type of company perceived barriers that should concern the other types of companies. For example, retailers were concerned with (manufacturing) cost, manufacturers were concerned with the lack of a business case and sacrificing aesthetics, and design consultancies believed inclusive design was not of interest to their clients and hindered them from pursuing trends. However, the authors did not provide recommendations for how to address these perceived barriers. In addition, they also found that retailers perceived a lack of awareness for ID as a barrier, echoing the finding by Vanderheiden and Tobias [35,36] that there was a lack of expertise on accessibility at organizations.

Two more recent studies used interviews and grounded theory to dig deeper into the process and rationale of fostering accessible design. In his dissertation, Law [17] conducted in-depth interviews with 20 professionals at 10 companies in different sectors that have successfully practiced accessible design. Based on a grounded theory analysis, he established a framework for seven organizational practices that were required for successful accessible design. These support many of the previous findings in further depth: executive support was necessary, for example, as well as access to expertise and resources. More recently, Leitner et al. [20] interviewed a set of managers in Austrian companies, examining the rationale, incentives, and barriers for creating accessible websites. In addition to interviews, Leitner et al. also analyzed the accessibility of the company websites and drew from organizational reports. They corroborated many prior findings, adding that a culture of social responsibility in the company influenced the accessibility of the product. In addition, they emphasize the role of project “initiators,” people who drove projects forward. In cases where products had accessibility barriers, initiators were often not convinced, prepared, or aware of accessibility. Related to our research question, they briefly noted that companies that practiced accessible design successfully implemented knowledge transfer tools, but they did not expand on this point.

The research described above underscored certain themes. In terms of organizational factors, it has been well established that accessibility knowledge within organizations was concentrated in a single or small number of experts, while other employees typically lacked the awareness or practical knowledge needed to make products accessible. In larger companies, the experts who drove accessibility work as a centralized team (Law refers to this as the “Accessibility Program Office”), and in smaller companies, the experts were often “champions,” individuals who voluntarily advocated for accessible design. However, as Law pointed out a decade ago, it is still unknown how this small number of experts disseminates knowledge and educates their colleagues in different roles and on different teams [17]. This sharing of knowledge is critical for a small number of practitioners to affect a broad range of products produced by a large organization.

2.3 Assessing Accessible Design Resources

While our study focuses on interacting with colleagues within an organization, there are known public ways in which accessibility experts—in public and private sectors alike—share knowledge to technology practitioners at large. These resources include sets of standards, guidelines, and tools that are publicly available online. The most prominent of these resources is the Web Content Accessibility Guidelines (WCAG), developed by the World Wide Web Consortium, which are frequently used by practitioners in the United States. Several scholars have studied these resources, aiming to understand their usability, prevalence, and effectiveness in supporting accessible digital content. In addition to general guidelines like WCAG, companies who develop platforms often release accessibility guidelines for their platforms, including Google's Android guidelines [43], Apple's guidelines [44] and Microsoft's Windows App guidelines [14]. These provide a standard for third-party developers who develop applications for these platforms.

Several researchers surveyed web developers to understand their use and perceptions of web accessibility resources [9,10,13,19,24,28,45,46]. They wanted to know why much of the web has remained inaccessible, despite the introduction of guidelines and tools. Survey questions queried respondents about their familiarity and comprehension of web accessibility guidelines in addition to a few questions about their perceptions of organizational factors influencing web accessibility, relating to research described in the previous section. Lazar et al. [19] surveyed 175 website masters and found that as many as 78% were familiar with WCAG and 98% said their websites were accessible at the time. These were by far the most optimistic findings among these surveys, which probably resulted from Lazar et al.'s sampling method: it seems they used convenience sampling from their university and personal networks, which naturally included like-minded individuals who prioritized accessibility. Around the same time, the Enabled Project conducted a survey of webmasters. They recruited 269 respondents through their partners and a health-related foundation (the exact methods are unclear) and found that only 42% were familiar with WCAG and most felt they did not have enough knowledge to make their websites accessible. Rosson et al. [28] revealed the most pessimistic findings; in a survey of 334 professional and hobbyist web developers, they found that only 5% performed accessibility tests.

While the surveys described above targeted web developers at large, the Web Aim project conducted an extensive survey of 724 web accessibility practitioners in 2018 [45]. A slight majority felt that web accessibility had improved in recent years. Of note, they found that very few had formal training in accessibility, learning about their work from online resources, colleagues, and on-the-job training. Although they heavily used online resources, most thought WCAG was only "somewhat understandable," indicating that they may not be a usable or sufficient reference for practitioners, let alone web developers with no accessibility training.

Choi et al. [4,18] conducted a heuristic evaluation of several accessibility standards and guidelines from English-speaking countries to determine whether they were usable by designers. They developed a set of heuristics, categorized under four principles, and conducted a heuristic evaluation by four experts. They found that the most severe violations were for heuristics under their second principle, "Support the design process and psychology." Heuristic 2.3: "Designers should be able to bring past experience into prescriptive problem-solving activities" was violated most severely, with severity scores of 3 out of 4 for six out of the eight resources they evaluated. Unfortunately, the authors do not provide recommendations for ways to address these violations.

In a related paper, Alonso et al. [1] investigated the usability of the WCAG guidelines for novice programmers. They tasked a set of 17 students with assessing the accessibility of a website using 25 "level-A" success criteria offered by WCAG. The assessments were done manually, since

no automated tools were available at the time. They found that the students were only able to assess whether the website met eight of the 25 criteria, because the others lacked sufficient detail or specificity. Even with expertise, however, assessing accessibility in website was challenging, according to Trewin et al. [34]. They surveyed 49 web developers at IBM and found that existing tools were difficult to use.

Law et al. [16] argued that even when accessibility professionals assessed websites, their reports were not appropriate for programmers. Programmers, not accessibility practitioners, were the ones who fix the problems identified so the evaluations should target their needs and processes. To address this discrepancy, they provided a step-by-step process that specified how evaluations should be conducted and reported such that they address the work process of programmers and product managers.

This research shows that despite the availability of public resources that detail how technologies can be made accessible, it was difficult for novice programmers as well as accessibility experts to implement the guidelines. The public resources were clearly not sufficient to help practitioners produce accessible products, indicating that accessibility experts must be the ones to educate their co-workers on these practices. Further, even when implementing the guidelines successfully, researchers found that websites still posed accessibility challenges. When studying the actual challenges that visually impaired users faced while browsing the web, Power et al. found that half the issues were not covered by the guidelines [23]. We aim to understand how these experts use guidelines and other resources to draw best practices for other organizations to follow.

3 METHOD

The purpose of our study was to understand the ways in which practitioners promoted accessibility in their organizations to foster accessible products. To that end, we draw on *reported practice*, a longstanding approach to understanding practice [11]. Specifically, we conducted semi-structured interviews with accessibility practitioners, who we define as employees whose work responsibilities involved the accessibility of products in some capacity. To narrow our scope, we focused on prominent, large companies that produce technological artifacts such as a website, software, or hardware devices. For example, such companies include Google, Apple, and Amazon¹. These companies produce many products that are used in schools and the workplace. Equal access to their products has become essential for fully including people with disabilities in society.

3.1 Participants

We recruited a total of 31 participants. During our interview with one participant, we realized that he did not meet our inclusion criteria, so we dropped his interview from our analysis. This resulted in 30 participants (22 male, 7 female, 1 declined to state their gender) representing 13 companies. To preserve their anonymity, we do not provide their specific job title (many titles were more specific than simply “program manager” or “developer”), and do not reveal any

¹ To preserve participant anonymity, we do not indicate whether employees from these specific companies were involved in our study. They are only examples of types of companies that we targeted for recruitment.

identifying information about the companies they worked for. However, we grouped participant codes by company (e.g., A1-A5 worked at the same company) and indicate their general role (as described in Section 4.1).

Participants’ ages ranged from 23 to 65 years, with a mean age of 40 years (SD=9.5; one participant declined to give their age). In terms of their education level, 24 participants had a bachelor’s degree, five had a master’s degree, one completed high school, and one had only completed some high school. About one third of the participants, 10 out of 31, reported having a disability.

Participants held a variety of roles related to the design, development, or management of the accessibility of products produced by their organizations. Examples of roles included product managers (5 participants), designers (5 participants), program managers (7 participants), managers or executives (4 participants) and engineers (8 participants). Participants’ seniority levels spanned from junior associates to Vice Presidents and Directors.

Our recruitment methods included convenience and snowball sampling, as we also sought participants who represented a diverse set of large technology companies. Our recruitment process spanned eight months, between fall of 2018 and spring of 2019. Throughout this time, we reached out to potential participants through our own professional networks, searched for potential participants on social networking sites (e.g., LinkedIn), and personally contacted them during an assistive technology conference (namely, the “CSUN Conference on Assistive Technology”). We gave each participant a \$40 Visa gift card to compensate them for their time. The study procedures were approved by our universities’ internal review boards.

Table 1. Basic participant demographics. We use the same letter to indicate that participants worked for the same company (e.g., A1 and A5 work for the same company).

Participant	Gender	Role	Participant	Gender	Role
A1	Male	Central	G1	Male	Embedded
A2	Male	Central	G2	Female	Central
A3	Male	Champion	G3	Male	Embedded
A4	Male	Champion	H1	Male	Central
A5	Decline to State	Champion	H2	Male	Central
B1	Female	Central	H3	Male	Central
C1	Male	Central	I1	Female	Central
C2	Female	Central	I2	Male	Champion
D1	Male	Central	I3	Female	Embedded
D2	Male	Central	I4	####	Champion
E1	Male	Central	J1	Male	Central
F1	Male	Central	J2	Female	Champion
F2	Female	Embedded	K1	Male	Central
F3	Male	Embedded	L1	Male	Champion
F4	Male	Central	M1	Male	Embedded

3.2 Procedure

The study included a single session, where we conducted a semi-structured interview that lasted about one hour. All interviews were conducted over the phone or video conferencing software such as Skype. All participants were interviewed individually except for A1 and A2 who worked for the same company and requested a joint interview.

We began each interview by asking about participants' demographic characteristics and professional and educational background. We then asked questions in three categories:

- **Organization characteristics and culture.** Examples of questions included: What consumer-facing products does your company produce? Describe the culture in your organization; How does your company view accessibility? Are you satisfied with the level of accessibility in your company?
- **Role and responsibilities of the participant and his or her co-workers.** Examples of questions included: How long have you been working on accessibility? What are the responsibilities associated with your role? Tell me about a typical day.
- **The lifecycle of a specific accessibility feature.** We asked participants to select a specific accessibility feature to discuss and asked them questions about the four phases of the feature lifecycle: analysis, design, development, and evaluation. Examples included: How was the need for this feature identified (for example, customer advocacy, a user study, the need to comply with a certain regulation)? Describe who was involved in the design of the feature? Was feedback collected from target users after the feature was launched?

Questions varied depending on the participant's role. Most participants were not involved in the complete lifecycles of particular features, so perspectives of the lifecycle varied based on which portions they were involved in. We asked multiple probing questions to understand exactly how and why participants interacted with their co-workers, within and across teams and levels of management.

3.3 Data Analysis

We audio-recorded all interviews and had them transcribed by a professional service. After data collection was completed, two researchers iteratively coded the transcripts using open codes. They began by independently coding the same set of three interviews, then discussed the codes and created a preliminary codebook. They repeated this process two more times, iteratively refining the codebook, until they agreed on the definitions of all codes. They then split the remaining transcripts and coded them separately according to the codebook.

4 FINDINGS

4.1 Accessibility Practitioners Roles and Responsibilities

Participants' titles varied, but their roles roughly fell into three categories. They worked on a centralized accessibility team (17 participants), worked as accessibility practitioners embedded in a product team (6 participants), or held another role and championed accessibility in addition to their main responsibilities (7 participants). Hereafter, we refer to participants' roles as "central," "embedded," or "champion."

4.1.1 Central Accessibility Teams. According to our study, central accessibility teams included employees in various roles (e.g., designers, software engineers, program managers) who had expertise in accessibility. These teams interacted with product teams across the organization and were typically located in divisions that were broadly responsible for design and user experience, or legal and compliance issues. In one company, there were two central accessibility teams, one under a design division and one under a compliance division.

J1 felt that working under a division that focused on design was important, because it allowed his team to focus on integrating accessibility earlier in the process. He explained that as companies became more experienced with accessibility, they tended to shift the central accessibility team from an engineering division to a design division. This allowed them to be more proactive and consider accessibility earlier in their product lifecycles:

A lot of companies, their accessibility teams start out in engineering, and then they move gradually towards design. I think that gives them a better foundation of knowing where accessibility sits within the company and the products, knowing what products are good what products are not, what teams need to be educated and such. I think that helps starting in engineering, but eventually you have to move to design so you can build it in the very beginning. (J1, central)

Companies that placed accessibility under divisions responsible for legal and compliance issues did so because of the need to comply with accessibility regulations such as Section 508 of the Rehabilitation Act. These divisions typically included teams focused on security, who also had to work across the organization to ensure that products adhered to certain regulations. H1 described the similarities between the ways in which accessibility and security teams worked.

The way that I would say it is that the security team and accessibility team have similar ways of interacting with the products. ... And, that is, we both are establishing what the bar is for our respective areas, accessibility and security, and we set up systems to help monitor where the products are at, and we provide technical guidance for the product around what they, you know, how to address the shortcomings that they have. (H1, central)

The responsibilities of the accessibility teams were thus very broad, with a heavy focus on educating co-workers in their company. As J1 explained, “Every day is different. It could be code checking. It could be design reviews. It could be building a prototype or working with champions, writing training materials. There is no standard day.” The official focus of most participants was company wide product accessibility, but they ended up serving as a resource on other disability-related issues across the company. This included issues related to ensuring the workplace was accessible and employees with disabilities were hired. C2 described her team’s broad range of tasks:

So our accessibility team is focused specifically on product and making sure our products are accessible. That being said, we work with other teams within our company to make sure that other components of our workplace is accessible. So that could include consulting with various teams on how we could hire people with disabilities, how we could hire people with accessibility knowledge, but also making sure that all of our events are accessible in terms of having like captioning. But accommodations specifically go through HR. We just are a central force

that people know and are aware of. If they have any questions, we can point them in the right direction. (C2, central)

With respect to ensuring products were accessible, the central accessibility teams served as a resource to product teams and provided oversight to ensure accessibility was incorporated into products. The accessibility teams were relatively small, so they relied on product teams to do so. H2 underscored this, stating that his role was “*about spreading out the expertise versus centralizing it. So everybody learns how to fish, so to speak.*” This demonstrated how critical it was for the accessibility team to educate, manage, and oversee a large number of co-workers across different product teams.

Central accessibility teams were points-of-contact for employees across their companies. I1 described her team’s approach as a “hub and spokes” model. They interact with delegated representatives from different product teams throughout the lifecycle of the products. She explained:

We’re the hub. And so when a new product is coming out, we have people on our team who sort of own the relationship with each engineering team. ... we have a person on our team who sees what the road maps are for those products, gives feedback very early on in the process of design, and when we get close to release we do some sort of quality assurance validation to make sure that everything that was committed to is being delivered. Hub and spokes approach. (I1, central)

4.1.2 Embedded Accessibility Practitioners. Several of our participants were embedded into teams or divisions that were dedicated to large products. These embedded specialists could be full teams or individuals. While the central accessibility teams focused on aspects of accessibility throughout the entire company, the embedded teams focused on practical implementation of accessibility in their product. This required close contact and integration with the product teams, which allowed participants to understand the culture of colleagues on the product team. F2 described her team’s role:

So we have this kind of core team of people who are focused 100% on accessibility and whether it’s on ... The engineers are mostly working on, again, building the features, and helping to fix the bugs, and improve compatibility, and performance, and all that. As a program manager, I work a lot of my time not only with the core engineers, but also working across the more general product managers, designers, and engineers across the broader teams on helping integrate accessibility into our broader processes. (F2, embedded)

The embedded accessibility practitioners worked on two types of features. First, they ensured that the products were generally accessible to people with disabilities. Second, they worked on features that were specifically designed for people with disabilities, such as creating built-in assistive technology for the company’s platform. Two participants (F2 and F3) described the need to implement features in their products to ensure compatibility with screen readers.

Beyond features for users with disabilities, they worked with members of the product group who were focused on sections of the product that were used by everyone to ensure that other products were accessible.

Some of the embedded practitioners focused primarily on making the complete ecosystem of products within a company more accessible. For example, some participants worked on larger teams that focused on creating the core components used by all products. These component libraries increased the consistency of user experiences and design across all products in the company, while also improving accessibility. As G3 said, *“You invest in the components and then when a bunch of other designers use them, they get these accessibility things that we intentionally put in for free. You don't have to think about it much. It gives us more control over the product quality, in the end.”* The practitioners tried to minimize the amount of work required by their co-workers to make a product accessible.

F3, who worked on an embedded team, summarized the different roles of the central team at his company and his embedded team, emphasizing that, ultimately, accessibility should be everyone's responsibility.

We do have a central accessibility team, which they are responsible for testing, documentation, guidelines and so on so forth. And there are accessibility teams within different product areas. And you know there's always this effort of engaging just a mainstream community inside the company to care about accessibility because ultimately, it shouldn't just be the accessibility teams to make our part accessible, and so even though I said we, I actually mean also, just people from [Company F]. (F3, embedded)

4.1.3 Accessibility Champions. Beyond the accessibility teams, most companies represented in our study had many champions, individuals who advocated and promoted accessibility. In some cases, they voluntarily took on this role beyond their official responsibilities. These champions increase the reach of the accessibility team, serving as “mentors” and “teachers” (I2). E1 felt that *“one of the good things with [his company] is that we're only six people but we've got easily 200 accessibility advocates throughout the company.”*

Interestingly, one of the companies in our study formalized their accessibility champions program. J1's company implemented different levels of champions, providing internal recognition for their expertise and level of training. J1 described the different levels for champions:

The majority of them are level one, which means that they've gone through disability etiquette training, their computers are set up for testing, they know where to get information, so they know they're tied into our slot channels and things like that. ... Then the level twos are the people that we've identified as core team members that are distributed around the company. And then level threes will become the subject matter experts. (J1, central)

Whether or not champions had formal roles, participants found that they played an integral role in ensuring the products were made accessible.

4.2 Engagement and Communication Channels

As mentioned above, the primary responsibilities of accessibility practitioners involved educating, managing, and overseeing co-workers. In particular, educating others about accessibility and

disability-related issues was an important aspect of their role. In this section, we describe avenues through which they educated and communicated with others across their companies.

Many of the participants described formal training sessions or presentations that they developed to teach co-workers in different roles about accessibility. Four participants described training sessions that were incorporated into new-hire orientations. Other training sessions were done over lunch or as one-off presentations.

The new-hire training sessions seemed particularly effective. They had a formal curriculum, where the accessibility experts began by teaching about general disability issues, including demographics and assistive technologies. In some cases, they then provided an introduction to more specific implementation details about how to make products accessible. However, the main goal of these sessions was to create general awareness of disability and accessibility issues, creating a culture and expectation across the organization. C1 explained:

And so they hear, on their first day, how committed we are... and that we expect the products and services and things that they do and make to be accessible to everyone, and so we capture them on their first day, and that way later, when they go back to whatever team they go to, they can never say "I wasn't aware" and can never say "I didn't know." (C1, central)

Some training sessions were extensive. E1's team led a five-day internal conference where they taught co-workers about topics ranging "from the accessibility process, to coding, to testing, to understanding the guidelines, communicating certain tool kits that we have that have accessibility built into it that they can use, platforms, and so forth." K1 was involved in establishing a week-long accessibility program for all new designers hired to the company. With many employees at a large company, K1 felt that this new-hire training session was an effective means of ensuring that designers across the company understood that accessibility is essential to their role at the company.

There's just like lots of designers pouring in, but they have, what we have done is put a week-long accessibility program in their orientation, in their bootcamp. So we're able to really create that culture for right off the bat, with the new employees. And they know when they come in that they just have to do accessibility. They understand that. (K1, central)

One important part of these training sessions was allowing users to "put their hands-on different technology and understand why it works and why it's needed," as C1 explained. Many incoming employees had not had any prior training or exposure to disability or accessibility, so it was important to show them how people with disabilities used their products. G3 described exercises in their training session where co-workers used screen readers. C2's company set up an "accessibility lab," which included a variety of assistive technologies, such as screen readers, head mice, and alt keyboards. There were training sessions in the lab for new hires, allowing them to try out the different technologies.

G3 emphasized that the purpose of the accessibility lab, and the experiences with assistive technology that it afforded, was not to generate empathy. Rather, it was to show co-workers that what people with disabilities *can* do—to demonstrate that they do use the technologies albeit in

certain ways. It showed co-workers that their designs can make them usable (or not) to people with disabilities. C2 explained:

The biggest thing is obviously empathy is going to be created no matter what, but we don't consider our accessibility lab an empathy lab. We focus on how assistive technology is being used to create access. So employees will, first of all, want to have experience with assistive technologies that a user with a disability might be using. But instead of pointing out what they can't do, it's pointing out what they need to do in order to ensure accessibility of what we're doing. (C2, central)

Ten participants held office hours, where employees could come ask questions or get advice about accessibility. Unlike training sessions, this format provided a way for employees to interact with the accessibility team as needed, when specific issues came up relating to the design and development of their products. After colleagues were aware of accessibility and the presence of the accessibility team, office hours allowed the accessibility team to serve as a resource for specific implementation guidance. L1 held an office hour every two weeks, explaining that questions “can vary from, ‘How do I implement this?’ to ‘Is this the right decision to make?’”

In addition to training sessions, presentations, and office hours, participants communicated with co-workers through asynchronous digital channels like Slack, email, and internal instant messaging tools. Like office hours, these channels provided a way for co-workers to seek practical guidance. I4 described the purpose of these types of channels: “If they have a rough issue within accessibility in their software and they don't know how to fix it in some way, they can ask questions.”

However, because digital channels were not in person, it was difficult in some cases for the accessibility professionals to give meaningful guidance. As C2 said about working through issues digitally, “there's only so much you can do via email. It really requires having the assistive tech there and having the experience there and then also having the people there to assist and help if the product teams don't have the resources to complete it.” The digital channels did provide important starting points that often led to in-person interactions.

4.3 Using, Modifying, and Creating Accessibility Resources

Participants described the use, creation, and dissemination of accessibility resources, as part of their effort to teach others about how to design and ensure accessibility. Eighteen of the 30 participants explicitly described use of publicly available guidelines. Most referred to WCAG, discussing the need to comply with Section 508. Three mentioned the need to comply with EU and Canadian regulations as well.

Several participants viewed WCAG as a baseline measure of accessibility, which they ultimately sought to exceed. A2 felt that meeting WCAG was just a “bare minimum.” As I3 explained, meeting this minimum ensured you complied with regulations, but it did not ensure you produced a usable product for people with disabilities:

The bar is typically minimum compliance. I think every company and even every organization battle with that, on how they're going to approach accessibility because you've given the standard and the guidelines available on accessibility within each country. You can meet the bar, you can be compliant, however, but not really meet a user's need. (I3, embedded)

H2 echoed this sentiment by describing WCAG as a mere starting point:

Well, [meeting WCAG is] a "yes, and..." I mean, I think compliance and standards have their place, again to help to drive people towards at least having a baseline experience, then we can build on top of to create more inclusive experiences. ... So I'm glad that they're there but people often mistake them for the standard to meet, versus the standard to exceed. (H2, central)

As a result, participants spent a considerable amount of time modifying, consolidating, and adding to the publicly available guidelines.

Many participants discussed the importance of translating the publicly available guidelines into something that those without a background in accessibility (like a typical designer) could understand. This was especially true for large companies, according to G3, because much of the responsibility of implementing the guidelines fell upon individuals who did not have accessibility expertise. He explained that his team "wrote documentation internally; we would take the WCAG Guidelines and sometimes make them less, translate them, make them more approachable for people who might find them too dense or too technical."

Four of the participants (E1, F1, I4, M1) consolidated multiple laws and guidelines into customized internal standards. F1's "internal standards [were] based off the external standards" from which they develop internal measuring tools. Two participants mentioned extensive efforts by the companies to include global standards and laws into their internal guidelines. E1's team "[created] a knowledge base internally, where we encompass all the guidelines. W3C, the Web Content Accessibility Guidelines 2.0, double A double A, and Section 508, Revised Section 508." I4 echoed this sentiment, saying that their lawyers take the highest bars of accessibility laws and standards from different countries in order to develop the internal standards.

Part of the process of consolidation was simply translating the wording of the guidelines into more comprehensible language. Both A5 and G3 created copywriting guidelines to ensure that the language used on website designs was accessible, G3 said "[we started] internal copywriting standards around inclusive copy... Maybe things like "look for" or "see more" or "view all" that are really common in digital products, [we could do] better by just using different language." A5 echoed this, pointing out how valuable of a resource it was for non-experts, "People go to that to help understand how to write and not use words like below and red button and things like that."

In addition to consolidating and translating existing guidelines, participants often had to expand or create new guidelines. The WCAG, for example, are updated infrequently (the last update was 10 years after the previous version), so technology changes could make them inadequate or obsolete. In addition, advocate communities, which affect disability discourse in general, evolve as well and reveal gaps in the guidelines. A2 described updating guidelines in response to changing technology and new attention to cognitive disabilities:

And there are times when we hear about stuff that people are talking about within the industry that aren't technically covered in the guidelines. That we will implement changes that we think would be useful, that aren't covered. Because the guidelines have their issues. So one of the big ones is that they don't really have a lot of focus on people with cognitive disabilities. (A2, central)

Another limitation of WCAG was their focus on the web, so participants in certain companies (producing hardware, or native applications) found that the WCAG and other existing guidelines did not cover certain technologies or use cases. For example, F1 was involved in the development of virtual reality applications, a platform with no existing accessibility standards: Creating completely new guidelines was a challenge, and F1 preferred to have an established standard. He said “there was no such thing as a screen reader for three-dimensional space... that’s a significant technical arc that we have to invent... so we did what we could but there wasn’t anything official. It wasn’t what I wanted.”

While homegrown guidelines were often forms of innovation and successful resources for non-experts, participants raised a series of issues. These included lack of consistency or internal agreement over what should be outlined, old or outdated guidelines, and unvetted guidelines that were written without feedback from others in the organization. Two of the participants (M1 and A5) talked about challenges with these homegrown guidelines. M1 noted that the lack of transparency around who created the guide made the guides less trustworthy and effective. A5 noted that an internal how-to guide was outdated because it wasn’t created or maintained in an organized way. By contrast, WCAG and other publicly available guidelines were developed with a more methodical and transparent process.

4.4 Enhancing Internal Tools

Many participants worked on their company’s technical infrastructure in order to improve the accessibility of their products. This involved improving their component libraries, tools, and testing processes to simplify the process for other practitioners to be able to include accessibility in their user-facing products.

A common approach was to focus on adding accessibility into the component libraries. Many of the accessibility practitioners we talked to were concerned with making accessibility a low-weight addition for their designers and developers. Including accessible components in libraries reduced developer workload. A developer could simply select the component from the library and only add a minimal amount of information to ensure accessibility. H1 describes the process:

And we do work to make sure that the UI frameworks themselves support accessibility, with the idea being that when a new product uses this UI framework, that they’re not creating more issues, they’re hopefully minimizing issues.

Furthermore, the tools used by the designers and developers could decrease the need for expertise in accessibility. D1 describes a change he made in their development environments to improve accessibility by alerting developers as they are coding to potential accessibility issues:

So we have interventions where if you are implementing something in your development environment and you say, for instance, pull in a component that we know needs to have a label, we can chirp you to say, ‘Hey, looks like you’re using this component. This component requires an accessibility label in order for it to be understood by somebody who is using a screen reader, please apply label.’ (D1, central)

In addition to reducing the expertise needed to implement accessibility, the tools also ensured consistency. D1 described another scenario where they modified the design and development tools so that when selecting components for design mock-ups or for development certain colors were

standardized. Instead of having the designer or developer select a shade of blue that might not meet contrast requirements or fit branding requirements, the color was automatically specified.

Finally, many focused on automating as many of the accessibility tests as possible. A2's "general testing strategy" was "to do as much of the testing via automation as possible. It just saves time for humans, that's just generally the best practice." While complete automation was an ultimate goal, in practice, A2 admitted that most of the accessibility tests still required human judgment:

So, of the accessibility guidelines, that checklist with 70 some items. Maybe if I was being very generous, 30% of those could be automated. 30% of those checklist items could be automated. That's not a guarantee you'll find all those issues. But you can automate 30% of those. The rest of it needs to be done manually. (A2, central)

4.5 Incorporating Accessibility into the Product Lifecycle

Writing specifications was a common way for a designer to communicate with a developer about the requirements of a feature. Many participants found that including accessibility in the specifications was crucial to ensure that accessibility was incorporated proactively. However, specifying design details that made a product accessible was challenging in several ways.

"Under specification" was a common problem that was mentioned by multiple participants. Participants would find that the accessibility information was often left out of the specifications. For instance a specification might detail the mouse interactions for a product, but not include any details about how to make the product keyboard accessible. J1 stated:

If the designers don't specify it, then the developers have to guess. And the problem was over the years, we had lots of minimal specifications, so the developers had to guess a lot, and we needed to clean up that guessing. We needed to clean up where accessibility had not been considered. (J1, central)

This was echoed by I1, who discussed use of color as an example. If the specification did not list the exact value of the color (e.g., "0000FF"), but just a generic name (e.g., "blue"), then the developer had to guess which version is meant. H3 found that the issues went beyond requiring the developers to guess in some cases, "because the designers don't say you need to do it, and the engineers only do what they're instructed to do." They found that if they didn't include something in the specification, then it wouldn't be done.

Other times, the developers would not be able to implement a specification as requested as accessibility was not considered in the specifications. H3 said, "So a developer will then take a design that they don't know how to make [accessible] and will change it into a design that's similar that they know is accessible and that they know how to do." This can lead to conflict between the designer and developer as there are conflicting interests of the designers preferred design versus the accessible design. This is where H3 got involved as he tried to determine if it was possible to make the initial design accessible, and, if so, help determine the technical details of that implementation.

Design reviews were common to determine if the design of a product met expectations. One of the participants mentioned that their team held separate reviews for the general user experience

of their application and one for accessibility. Two reviews were more time-consuming in the short-term, but they decreased the number of bugs found and saved time in the long-term:

I think there's, from the studies we've done, there's been 40 and 50% decrease in the number of issues that they've had to fix later on in the process. And we know as an industry that later on in the process requires more people which means it requires more time and more money for the company.” (I2, champion)

4.6 Talking about Disability

Discussing disability was fundamental to participants' communication with stakeholders and was a critical aspect of their advocacy for accessibility. One approach was showing the intersection of the needs of people with disabilities and the needs of people without disabilities to make the topic relatable. Another prominent approach was to make the needs of people with disabilities concrete to designers and developers by leveraging real user feedback.

Many participants framed the needs of people with disabilities as “mainstream” needs that were common to those who did not identify as disabled. M1 explained how his view of accessibility evolved, “I always thought of accessibility as designing for people that have these permanent things, but I've realized so much of it is also designing for people with situational disabilities or temporary disabilities, like somebody that's broken their arm or just has access to one arm for a temporary situation because they're holding a pole on the subway or whatever, right?” Introducing concepts of situational and temporary impairments was a common approach, with others giving examples of users having the sun in their eyes (I1) or reading on a train (L1).

F1 felt that addressing situational impairments, which are experienced by everyone, would be prioritized by their co-workers. Instead of appealing to a moral case for inclusion, he opted for presenting a practical one when talking to his colleagues. He demonstrated this by focusing on “eyes-free” use cases rather than blind people's experiences when speaking with his co-workers:

That's one of the arguments that works best for me. I have to change my language. If they're talking about what are you doing for people who are blind, I talk about what are you doing for an eyes free use case. ... When you speak their language, their language is priorities. (F1, central)

As another example, participants presented the need for keyboard navigation in terms of a mainstream use case rather than a disability-specific one. People who use screen readers or other assistive technologies must interact with a computer via the keyboard (e.g., by using the “tab” key to move from one UI element to another). However, many “power users” also navigate an interface using a keyboard to save time. Participants often presented the “power user” use case and incorporated this into specifications. This appeal to co-workers' practical nature, of impacting a broader audience, was interesting because the majority of our participants worked on accessibility because they thought it was “the right thing to do.”

According to participants, demonstrating an accessibility-specific use case was effective when made concrete. One way to make an experience concrete was to demonstrate how people with disabilities use a product with assistive technology. B1 recalled that “when [he] started to educate people on a demo, and I turned on a screen reader and kind of went through what I would go through trying to shop, it just sort of highlighted what customers could be feeling if they were using a screen reader or if they might be hearing impaired or whatnot.”

Another way of making an accessibility use case concrete was to bring to life the experiences of real customers. H1 felt that “... part of the reason [he] can be more convincing is because I have louder, noisier customers, who are making less easily put-aside demands.” Being able to cite specific customers can show that it is a real problem, not an abstract case. G2 echoed that thought, describing a time when she sent copies of Twitter posts mentioning accessibility issues with their product as a motivation. She found, “Essentially anything that has involved real users has been very effective for us.”

When developers or designers pushed back on accessibility features, claiming they were unnecessary, participants used user study data to persuade them. J1 gave an example of a time where the designers felt that the best way to convey the hierarchy of information was through color and that using light (low contrast) colors was the best way to convey less important information. Only after watching a user study, the designer was convinced that the change was needed. J1 recalled:

I remember one time we had a customer with low vision, and he put our page on an enormous monitor that he uses. When he got down the footer text, he still couldn't read it, even though it had been blown up tremendously, and he had to pull out the screen reader in order to read the leaves. That kind of user testing and user interviews, that's where the designers understand. (J1, central)

When discussing disability in our interviews, participants described use cases, guidelines, and technologies related to four disability categories: vision impairments, hearing impairments, cognitive impairments, and motor impairments. Most of the conversations, however, centered around vision impairments and, in particular, screen reader users. This focus on vision disabilities reflected participants' experiences within their companies. A few participants noted that cognitive impairments did not receive enough attention and were ignored by internal and public resources. M1 explained:

I think that the whole conversation still feels very centered around accessibility being around physical disability rather than being around thinking about cognitive disabilities or neuro diversity or inclusive design kind of thing. But I think slowly it's moving in that direction. That's an industry wide thing, it's not just at [my company]. None of their trainings talk about anything about cognitive at all. So it's mostly just like screen reader based, color blindness, considerations for – who are hard of hearing or deaf. (M1, embedded)

4.7 Engaging with Other Companies and Organizations

In addition to adhering to the public guidelines, many of the participants also played active roles in shaping and developing them. Seven participants mentioned that they were formally involved in the development of guidelines, sitting on standards bodies including those of W3C and WCAG, and one participant mentioned that they presented research to government bodies.

Participants saw their involvement as beneficial to the company and to the industry at large. D1 noted that they contribute to the W3C for the same reason that they open-source accessibility

tools that they've built, "because we don't want to just solve it for the [Company] case." K1 echoed this, saying that the company is at a better vantage point to ensure that vendors were doing the right thing and to stay on top of new WCAG guidelines and regulations.

For two participants, the process for designing a specific feature or product was informed by looking at what other companies did. This was framed as both looking at best practices and as market research. B1 noted, "And then [our group] discussed [the problem]... and we also looked at, obviously, competitive analysis and how other sites did, how other sites that are known to have an eye on accessibility were doing it and we just realized we're over-complicating this." Accessibility practitioners know what other companies have an "eye on accessibility" and look to one another's products through "benchmarking" and "market research" to inform their own product development. A2 echoed this sentiment, "We kind of follow what other people in the industry are saying that they're using as best practices." One of the participants, A5, talked about the potential benefits and risks of this type of mimicking:

Competitive analysis is a double-edged sword. Just 'cause everyone else is doing something doesn't mean it's right, but there are times where that is what people are used to seeing. It's a piece of data that you've added the rest of your decision making. (A5, champion)

Many of these companies tackled the same design problems, so they use the aforementioned forms of market research to work through their own design problems and challenges. In the instances described above, companies influenced one another through their products and reputations. In other instances, they directly supported, trained, and shared knowledge with accessibility practitioners in other companies. I4 noted that "within the space itself, I think there's more of a camaraderie... I think that there's, even in these areas where companies can be more competitive with each other, within the space of accessibility [there's] an option to bridge that competitive nature and allow people to work together."

G3 emphasized the value of receiving guidance from a company with a more mature accessibility team, "we were in the grass roots phase we were connecting with other companies... one of them was [Company]. [Company] had an Accessibility Team already and they were really generous to share time with us. We had video chats and calls with them. They were ahead of us." The amount of openness can depend on the company, however. H3 notes wanting to learn more from another company but not being able to: "Great people [at Company]. They have exactly the right mindset for doing this work... They've got it down. I just wish I could pick their brains a lot more, about how that culture has formed."

In addition to other technology companies, participants engaged with other organizations and institutions. For example, several participants worked with Teach Access, an initiative aiming to promote accessibility education in university courses.

5 DISCUSSION

Our interview study addressed an important gap in our understanding of accessibility practice. Specifically, we uncovered how a small number of accessibility practitioners promoted the creation of accessible products across a large company that produced many products. According to our findings, the placement and roles of the accessibility practitioners enabled them to have broad-reaching impact as they were able to interact with a large number of co-workers in several key ways. Practitioners on central accessibility teams served as resources to accessibility-related issues

across the companies by conducting extensive training sessions and creating and disseminating guidelines and tools; champions and embedded practitioners amplified the efforts of the central team and were able to be deeply involved in the implementation of accessibility and develop features specifically for people with disabilities. Regardless of their roles, however, accessibility practitioners were first and foremost educators, teaching others about accessibility and disability issues. Second to serving as educators, the practitioners developed and maintained resources (guidelines and tools) since publicly available resources were woefully inadequate. Finally, and of least significance, accessibility practitioners served as technology creators, contributing directly to the development of accessibility features.

As with design practice, we found that accessibility practice involves ongoing negotiations with stakeholders, advocacy, and complex collaborative processes. However, there were some notable distinctions. Our participants interacted with an array of stakeholders, including designers, developers, engineers, and program managers that worked on product teams. Much of their interactions with these stakeholders involved education and advocacy, intertwined activities that aimed to both teach others about disability and accessible design and advocate for its importance. According to Colusso et al. [6], in design practice, advocacy involves showcasing user research data and trusted publications to prove the value of certain design ideas. Stolterman [31] states that advocacy is done by “making [designers’] judgments visible and open for critique.” While participants in our study also described using user study data and other user experiences to advocate for certain designs, most advocacy was pre-emptive. Instead of arguing for specific designs, participants spent much of their time advocating for accessibility in general. This type of advocacy was done through, for example, new-hire orientations and other training sessions. When advocating for specific designs, guidelines were often used as justification. This shows at least one way in which accessibility practice differs from design practice, indicating that it merits its own attention from the research community.

Another distinction from design practice, as alluded to above, was accessibility practitioners’ reliance on guidelines. Although our study did not focus on resources per se, the need, use, and generation of guidelines emerged as a prominent theme. It seems that accessibility practitioners did not engage in much brainstorming and idea generation—prominent activities in design practice ([6,25])—but rather relied heavily on guidelines.

Within the accessibility field, there has been some research aiming to support practice. Researchers have proposed design methods (e.g., [29]) and guidelines (e.g., [2]). However, none of these account for the complexities of accessibility practice described above. As such, we advocate for further research on accessibility practice. As Stolterman argued, we need a deeper understanding of design practice in order to better support it. This applies to accessibility practice as well. In the following subsections, we identify research directions provoked by our study that can address this need.

5.1 The Effectiveness of Education and Outreach Activities

Our participants had formal and informal ways of teaching others about accessibility. They seemed to think that the most effective format were formal training sessions, especially those presented to all newly hired employees. Prior work, dating back to the late 1990’s, highlighted that technology practitioners lacked awareness of accessibility. Our study indicates that this is still the

case, as the main goal of the training sessions was to raise awareness for disability and assistive technologies. Vanderheiden and Tobias [36] suggested a different training model where companies would invite external consultants to conduct trainings, because most companies didn't have accessibility experts. We were pleased to find that all but one of the companies in our study had, at the very least, a central accessibility team (L1 was a champion for a company that did not have a central team). Smaller companies, which were beyond the scope of our study, likely do not have accessibility experts, though, so the consultancy model may be more appropriate. Either way, research is needed to assess the effectiveness of these training different kinds of education formats.

5.2 The Impact of Regulations

Regulations, as suggested by Vanderheiden and Tobias [35,36], can serve as an external force to ensure companies produce accessible products. From our interviews, we observed that regulations like Section 508 were sometimes the impetus for hiring accessibility practitioners or forming an accessibility team. As they gained more experience, the accessibility practitioners wanted to go above and beyond the regulations. They viewed the regulations and the associated standards as a starting point and sought to exceed them when possible. They aimed to educate, motivate, and guide co-workers to apply accessibility standards that exceeded the reach of the guidelines as well. While these were the first-hand accounts of the accessibility practitioners—people who spend their professional lives thinking about and advocating for accessibility—more research is needed to determine the impact of regulations on all stakeholders and examine how they ultimately affect the accessibility of products.

5.3 Accessibility Education in Colleges and Universities

Many of our participants felt there was a need to educate co-workers about accessibility, indicating that they did not receive sufficient training in their formal education. Colleges and universities have been slowly incorporating accessibility into their computer science and design curricula [30], however, it is unknown whether these curricula meet the needs of industry. In the company-run training sessions, the main goal of accessibility education was to raise awareness and foster a culture that elevate the needs of people with disabilities, demonstrate ways in which people with disabilities interact with technologies, and expose students to accessibility resources. It is important that the education is moved to the university level to ensure that accessibility does not only happen in the largest companies that have the resources to dedicate employees and time to accessibility education. Research is needed to develop standard curricular materials that serve the needs of industry and ensure they are widely adopted.

5.4 Generation of New Guidelines

Beyond general awareness, our participants educated their co-workers about the nuts and bolts of making accessible products. This knowledge was codified into guidelines and tools, which were based on publicly available resources. Prior work on accessibility resources found that existing guidelines were difficult to understand and apply for novice and expert practitioners alike [1,34]. Our study corroborated these findings and identified other gaps: different guidelines applied to different countries, and existing guidelines did not consider certain technologies (e.g., mobile and

augmented reality devices) and disabilities (e.g., cognitive impairments). While some researchers have aimed to fill these gaps—for example, Ballantyne et al. developed guidelines for Android [2], these have not received broad recognition—there need to be much more extensive efforts by the academic community to study how people with a range of disabilities interact with mainstream technologies, and develop actionable guidelines for technology creators. This is critical for small and mid-sized companies and other organizations who do not have the resources to create their own guidelines.

5.5 Developing Infrastructure that Incentivizes, Facilitates, and Automates Accessibility

When directly contributing to tool and infrastructure creation, accessibility teams had to target their work strategically. Many companies focused on decreasing the amount of work and knowledge that was necessary to create accessible products. Throughout the interviews, we found numerous examples of companies trying to use this approach to increase accessibility. These changes mirrored many of those suggested by Ross et al. who identified many factors that impact accessibility [27]. Accessibility practitioners try to address potential infection sites (places where inaccessibility could be introduced) at all points in the lifecycle. Many of the approaches that are discussed above were high impact activities that instead of affecting the accessibility of a single application, had the potential to impact the accessibility of every product the company created. This had the dual benefits of maximizing the effect of the work done by the accessibility practitioners and making the addition of accessibility light weight for the average designer and developer, increasing the odds that accessibility will be included. Several research efforts have contributed tools to facilitate and automate accessibility (e.g. [32,37]), yet most of these have served end-users, rather than designers and developers. More work is needed on such tools, along with evaluations of their use and effectiveness in practice.

5.6 Parallels with Other Practices

One of our participants (H1) noted the similarities between accessibility and security practice: both teams “set the bar” for the level of security or accessibility in the company, both provided guidance to stakeholders across product teams, and both monitored adherence to security or accessibility. In several companies in our study, the security and accessibility teams were located under the same organizational division; they both involve interacting with product teams across the organization. Prior work on security practice indicates that the parallels between these two practices go deeper, however. Thomas et al. [33] found that security had *champions* that voluntarily advocated for security in their organizations. Kocksch et al. [15] studied security practice through the lens of care, which they define as “the object of continuous, often collaborative tinkering and experimentation—efforts that spread across sites and scales and involve a range of diverse actors.” They state that caring for security involved constant oscillations between insecurity, with the need to define what is considered secure. In addition, they emphasize the moral nature of the practice, indicating that practitioners were “not in it for the paycheck.” This closely mirrored findings from our study, although we did not yet investigate them in depth. For example, as briefly noted, most participants said they practiced accessibility because it was “the right thing to do.” Participants aimed to define their own high bar for

accessibility in their companies, with one participant (C1), saying that he will never be satisfied with the level of accessibility in his company. These parallels should be investigated in further depth, as findings from one practice may help shed light on another. For example, Poller [21] found that a security audit, which included a several-day training session, did not lead to lasting change in a software developer team. He argues that security trainings should consider the routines and organizational structure of the software development team. Perhaps the same applies to accessibility training as well.

5.7 Limitations

Finally, we note some limitations and other directions for future work. Our study focused on the reflexive, first-hand accounts of accessibility practitioners. While this method is often used to gain insights into practice, it should be corroborated with other studies that take on other approaches. For example, it is important to observe daily practice to gain additional insight. In addition, it would be valuable to evaluate the effectiveness of the activities and processes described, along with the accessibility of the companies' products. Future work could compare the experiences and strategies of accessibility practitioners who worked for companies with more vs. less accessible products. Moreover, we indirectly described the roles and experiences of employees who were not part of our sample—they were not “accessibility practitioners.” Interviewing them would add additional insights into the ways in which they learn and incorporate accessibility into their work. Lastly, our study explores the experiences of practitioners at (very) large technology companies, and it is important for follow-up studies to explore accessibility practices at mid-sized and small companies as well.

6 CONCLUSION

Our research aimed to reveal how small numbers of accessibility practitioners promoted the accessibility of products in large technology companies. To that end, we conducted semi-structured interviews with 30 accessibility practitioners, people who were involved in accessibility in some capacity, at 13 companies. We found that these practitioners primarily served as educators, teaching their co-workers about disability and the importance of accessibility. They also created internal resources, which aimed to exceed publicly available standards and regulations in terms of scope and usability. Our findings indicate that, despite increased interest in academia, technology practitioners still lack awareness of accessibility. These large-scale companies had sufficient resources to dedicate employees to overcome current deficits of accessibility knowledge and the insufficient existing public resources. However, smaller companies may not have the resources to overcome these challenges. Thus, it is important for researchers to deepen their understanding of accessibility practice so that they can better support it.

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