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SYMPOSIUM

Equipment Repositories for Accessibility: A Model for Improving Access in Field Science

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Synopsis People with disabilities have been historically underrepresented in scientific fields as a result of systemic barriers and a "leaky pipeline" through academia. This has been especially true in field science, where a lack of resources and limited access to adaptive equipment have made accommodating disabilities in field settings seem daunting. This paper introduces the Equipment Repositories for Accessibility (ERA) model as a blueprint for universities to implement and improve the accessibility of field research and field-based courses. It first provides an overview of the history of disability in science and how systemic barriers contribute to underrepresentation and reduced access to field science. It then outlines the steps for the establishment and long-term management of the ERA model as a means of overcoming these barriers and provides a brief overview of the types of adaptive equipment available for a diverse range of accessibility needs. The scientific community benefits from the inclusion of diverse individuals and addressing barriers to accessibility is a necessary step in creating a truly intersectional academic community, which acknowledges the deeply interconnected nature of disability with other identities including race, gender, and sexuality.

Introduction

A disability is defined as any physical or mental condition that interferes significantly with one or more major life activity, such as walking, communicating, or working (Americans with Disabilities Act 1990). This definition is intentionally broad, as disability is complex and nuanced; no two individuals will have the same experience of disability even if they share a diagnosis. Of the roughly 8 billion people in the world today, it is estimated that at least 1.3 billion people have some form of a disability (World Health Organization 2022). Far from being rare, people with disabilities represent the world's largest minority group, and yet remain drastically underrepresented in many areas, including the scientific community (Booksh and Madsen 2018; World Health Organization 2022). People with disabilities are frequently excluded from the discourse on diversity in STEM and are overlooked as an underrepresented group in academia (Dali 2018; Lee 2022). While this lack of representation has been attributed to a number of issues, among the most prominent is a series of systemic barriers to access that make it difficult for disabled individuals to enter and remain in STEM careers (Friedensen et al. 2021; Wells and Kommers 2022). This creates what is referred to as a "leaky pipeline" effect, in which the representation of disabled individuals is progressively lost across academic ranks (Bittinger 2018; Booksh and Madsen 2018; Wells and Kommers 2022). Field-based science, which can broadly describe research or courses conducted in outdoor environments, is a particularly inaccessible space in academia in which scientists with disabilities are significantly underrepresented (Beltran et al. 2020; Chiarella and Vurro 2020). The most prominent challenge is that the field environment often presents substantial physical barriers to individuals with disabilities, which can limit participation in field-based courses or research. Providing adaptive equipment, referring specialized devices or technologies that help a disabled person to complete a task, is among the most direct ways to address these

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field-specific barriers; however, this presents its own challenges (Malkawi et al. 2019; Menzies et al. 2021). There is limited information on the types of modifications or equipment available for individuals who may be planning a field course or leading a research team and existing support structures like disability services centers at universities do not always oversee these accommodations needed for field work (Hall et al. 2002; Atchison and Libarkin 2016). Further, there are often significant financial and logistical limitations in accessing and implementing these types of accommodations, including adaptive devices (Hall et al. 2002; Menzies et al. 2021).

The intent of this paper is to introduce the Equipment Repositories for Accessibility or "ERA" model to act as a blueprint for addressing these limitations in access to adaptive equipment in a centralized manner at the levels where they can have the most impact within the scientific community. In this paper, I will explore the history of disability in science, technology, engineering, and mathematic (STEM) fields and the systemic issues within academia that contribute to underrepresentation in order to better contextualize the barriers that exist in modern field science. I will then discuss some of the specific accessibility challenges encountered in field settings and the wealth of adaptive equipment and assistive technology on the market. Finally, I will address the challenges individuals face in acquiring this type of equipment and introduce a simple, reproducible model for bridging gaps in access. The ultimate goal is to see the implementation of this model at universities and research facilities on a national or international scale to provide immediate improvements to the accessibility of field-based research opportunities and classes for disabled scientists at all academic stages. Improving the accessibility of field science is important for advancing diversity, equity, and inclusion (DEI) goals, benefitting not only individuals with disabilities but the scientific community as a whole. Field work encourages active participation in learning and is demonstrated to benefit education outcomes, narrow achievement gaps, increase undergraduate retention, and improve overall perceptions of research, particularly among students from historically underrepresented groups (Beltran et al. 2020). Further, there is evidence that the inclusion of diverse perspectives, including those from disabled individuals benefits the scientific community, bringing to the table valuable skills shaped through their unique lived experiences (Hofstra et al. 2020; Daehn and Croxton 2021). Given all of this, establishing a network of adaptive equipment repositories may serve as a valuable tool in improving the accessibility of field-based research in the scientific community.

Positionality statement

To provide context for this paper, I wish to acknowledge my identity and its role in developing the ERA model. I am disabled and my experiences in seeking out accommodations and adaptive equipment to conduct field research through my undergraduate, and current graduate education are the primary inspiration for developing this model. That said, as a white, cisgender woman with a visible disability and reliable access to healthcare, I wish to acknowledge there are aspects of disability I cannot directly speak to that are relevant here. My goal in this paper is to highlight the challenges by the field that broadly apply to disability; however, there are added safety and access concerns for BIPOC, LGBT+, and other marginalized groups in the field, and I wish to recognize these complexities.

Disability in STEM: a historical overview

Historic data documenting the representation of people with disabilities in STEM fields is limited, but the earliest records of disability status among scientists appear in 1985 on the National Science Foundation's (NSF) long-running annual Survey of Earned Doctorates (SED; NCSES 1985). It should be noted that since their inception, the definition of disability used and the ways in which it was quantified has changed several times. Disability was defined as exclusively physical in nature in the 1985 survey, while updates to the questions in 2010 and 2012 made this definition more inclusive of learning, cognitive, mental, and emotional disabilities (NCSES 1985, 2010, 2012). Additionally, more progressive language (see Box 1) was adopted, shifting from "Are you physically handicapped?" in 1985 to "Do you have the following disabilities?" in 2010, with the surveys after 2012 focusing specifically on how someone's disability affects their work (i.e., "What is the usual degree of difficulty you have with the following tasks?"; NCSES 1985, 2010, 2012). The NSF now uses the inclusive definition of disability laid out by the ADA in formal documentation and has progressively improved in their approach to surveying disability in the scientific community (Americans with Disabilities Act 1990; Office of Diversity and Inclusion 2023). More detailed information on the representation of disabled scientists became available in 1994, when the NSF published the first edition of the biennial report on women, minorities, and people with disabilities in STEM (NCSES 1994). These reports include reflections on career-related disparities between able-bodied and disabled scientists, but while older versions break down this information by disability type (i.e., mobility, cognitive, etc.), newer versions report all disabilites together (i.e., with disability vs. without disability; NCSES 1994, 2023).

> **Box 1 Language and terminology**
> The terminology and language used in discussions surrounding disability has changed dramatically over the last few decades, primarily as a result of the disability rights movement (Andrews et al. 2019). The predominant goal has been to eliminate the use of terms such "handicapped" and "retarded," with the majority of the community preferring to simply be identified as disabled. (Andrews et al. 2019; Zeigler 2020). Today, the terminology used can generally be classified as either person-first or identity first, where person-first language places emphasis on the individual (e.g., person with autism or individual with a disability), while identity first language refers to the disability before the person (e.g., wheelchair-user or disabled person). While person-first language is often considered the more "politically correct" choice, some disabled individuals prefer identity first language as they feel their disability is an integral part of their sense of self (Andrews et al. 2019; Ferrigon 2019).

One clear finding among these reports is that the limited representation of disabled scientists in STEM fields today is by no means novel. Roughly 11% of undergraduates in STEM, or about half as many as in the general undergraduate population report having a disability (NCSES 2017). This figure presents a marginal increase from the average of 9.5% documented in 1989 (NCSES 1994, 2017). Similar trends have been cataloged among graduate students; from 1992 through 2010, only 1–2% of the doctoral degrees in STEM awarded annually went to people with disabilities (CEOSE 2013). Even with the passing of the Americans with Disabilities Act in 1990, this trajectory remained unchanged, with an average annual increase in doctorates awarded to disabled students of just 0.009% (Booksh and Madsen 2018; CEOSE 2013). That said, representation among graduate students has improved significantly and the most recent data estimate that about 19% of students enrolling in STEM graduate programs are disabled (NCSES 2023). The percentage of graduate degrees awarded to disabled students still lags behind at 8–13%, pointing to the "leaky pipeline" effect described earlier (NCSES 2023). People with disabilities are also predictably underrepresented in the STEM workforce, within both academic and non-academic careers. As of 2021, only 3% of the STEM workforce identified themselves as disabled, a value unchanged since 2011 (NCSES 2023). Barriers in entering the job force, poor experiences in academia and a significant wage gap are commonly cited reasons for these disparities (Booksh and Madsen 2018; NCSES 2023).

Given what is known about representation in STEM more generally and the additional barriers to access present in field science, it is easy to predict that there is a significant lack of disabled representation in field science. There are no data available documenting the number of scientists that engage in some form of field research, and therefore the representation of disabled field scientists is also unknown. This lack of information limits our understanding of how institutional factors specifically shape the accessibility of field-based research or courses. In order for the scientific community to become more accessible, we need a clear picture of both the systemic and specific barriers to access, and how these might influence the ability of individuals to engage in field science.

Systemic barriers

Overview

Systemic barriers are "policies or practices among institutions or organizations that disproportionately affect some individuals, result in them receiving unequal access, or exclude them" (Accessibility for Manitobans Act 2013). These barriers affect the scientific community both broadly and in niche areas where accessibility and representation are particularly limited, including field science. The presence of these barriers, and the lack of resources or support necessary for disabled individuals to navigate them is one of the most common reasons that individuals leave academia or STEM fields altogether (Booksh and Madsen 2018). While there are numerous systemic barriers present in the STEM community, there are some that are more relevant in the context of field science, specifically academic ableism, and limitations in access to accommodations.

Ableism in academia

Ableism broadly describes bias or prejudice toward disabled people or the implementation of practices and policies that disproportionately affect them (Brown and Leigh 2018; Peterson 2021). In academic settings, this may manifest as inappropriate questions about someone's disability, physical inaccessibility of workspaces, or more serious issues like denying accommodations or employment discrimination. Addressing these kinds of ableist practices within the culture of academia has been a topic of increasing concern, with social media providing a platform for advocates to challenge the norms of the scientific community (Miller 2017; Brown and Leigh 2018). One of the most challenging forms of academic ableism, however, is also one of the least visible ones. Implicit biases toward disabilities perpetuate systemic barriers in both the scientific community and in society more broadly (Dovidio et al. 2011). Misconceptions about what a disability "looks like" or assumptions about someone's limitations can have profound consequences for disabled scientists on both personal and professional levels, even if these thoughts are subconscious (Dovidio et al. 2011); Brown and Leigh 2018). For example, it is a common misconception that all blind or deaf individuals are completely deprived of the affected sense, when in reality, the effects of these disabilities exist as a spectrum. Without recognizing this nuance, individuals may have their ability to complete certain tasks or even their disability as a whole questioned (Olusanya et al. 2019). How disability "looks" is also incredibly nuanced. It is estimated that 70–80% of disabilities are "invisible," or not visually obvious, and this can include chronic illnesses, neurodivergence, mental health disorders, and more (Kelly and Mutebi 2023). Other disabilities may fluctuate from day to day, prompting the use of mobility aids some days and not others; but this often raises accusations of faking one's disabilities or not actually needing the mobility aids. Despite representing the majority of the disabled community, individuals who appear able-bodied or who have fluctuating needs often find it exceptionally more difficult to gain access to accommodations in comparison to individuals with more apparent or static disabilites (Brown and Leigh 2018; Goodwin 2020). Conversations about disability are uncomfortable or unfamiliar for many, so addressing these misconceptions can be intimidating, especially if power dynamics are at play (Hodo et al. 2023).

The accommodations process

Whether acquiring them as a disabled student or an employee, the process of applying for and implementing accommodations is a notoriously challenging process (Bettencourt et al. 2018; Krebs 2019). Given that the purpose of these accommodations is to mitigate one's disabilities this seems counterintuitive, but concerns over perceived advantages have led to increasingly complex rules and documentation processes for acquiring accommodations, particularly in the last decade (Krebs 2019). Every university operates their accommodations system differently, but it generally involves meeting with an access counselor to discuss the ways your disability affects either academic or job performance, determining what accommodations (if any) you may benefit from, and acquiring the appropriate documentation to have your accommodations implemented. Timing can be a significant issue at many universities, where disability service offices are often overwhelmed and have more students in need of accommodations than they have access counselors to manage. This can result in substantial wait times in addition to the months-long application process, during this, individuals may have no choice but to work without accommodations (Bettencourt et al. 2018). Another major issue is the role of healthcare inequities on the ability to receive accommodations. The approval process for accommodation usually relies on having a physician-diagnosed condition that meets the ADA definition of a disability (Americans with Disabilities Act 1990). Although good in theory for assuring that individuals who request accommodations do in fact need them, in practice it is fraught with issues. If individuals do not have health insurance or reliable access to a physician, they may not have someone who can complete this step. Even with access to a physician, time constraints for filling out documents or providing inadequate detail may harm an applicant's ability to access specific accommodations. This can be further complicated by an individual's history with a physician or particular hospital system, and their ability to track down past medical records. Further, lacking a definitive or formal diagnosis for physical or mental health challenges may limit the accommodations you can receive. This also does not account for the pre-existing disparities and challenges faced by people of color, the LGBTQIA + community, and other minority groups in accessing and navigating healthcare. Collectively, these inequities in access to affordable, safe, and accessible healthcare can present significant barriers to establishing formal accommodations, and as a result many disabled individuals choose to avoid this process altogether (Cardoso et al. 2016; Krebs 2019).

Finally, and most relevant in the context of field science, is that there is rarely infrastructure for providing accommodations in field research, shifting the responsibility of arranging assistance, or tracking down adaptive equipment to the disabled individual (Peterson 2021). The cost and logistical aspects associated with this make accessing adaptive equipment very difficult, and many people may not know what equipment is available to them. These challenges make navigating the accommodation system a significant barrier to access, particularly in the context of acquiring accommodations for field research or field-based courses.

Disability in field science

Overview

As previously stated, there is next to no information available on how to accommodate disability in field science, and that is because it is very often avoided. Students with disabilities may be encouraged to avoid field-based courses or research opportunities, and graduate school applicants may find themselves afraid to approach research positions with physical requirements (Hall et al. 2002). Although there will inevitably be environments or projects with physical demands that are inaccessible regardless of any accommodations, with the right tools, many field-based studies can be made more inclusive to disabled scientists (Hall et al. 2002; Chiarello and Vurro 2020). With the wealth of adaptive equipment and assistive technology on the market today, and a flexible, open mindset, a future of accessible field science is within reach.

When considering barriers to access in a field environment, the most fundamental consideration is recognizing that every individual has different needs. Even a hundred individuals with the same diagnosis could all require different accommodations or adaptive equipment to access the same environment or conduct the same research; As stated previously, disability is an incredibly nuanced and personal experience, and what works for one person may not for another. The type of field environment in question is also important, as each presents specific challenges; for example, wheeled mobility devices can easily get stuck in sand, mud, or snow, and a noisy environment like a city could be overwhelming for someone with a sensory processing disorder. This section will explore some of the accessibility challenges in the field that can be specifically addressed by adaptive equipment and the ERA model. Although many of the accessibility solutions described here may be applicable across several categories, they are divided hereafter based on where they are primarily relevant.

Blindness and visual disabilities

Safe navigation and movement are the primary concerns for someone who is blind or has limited vision in a field environment (Malkawi et al. 2019). Ground cover and trip hazards are important to consider while moving through the field, particularly with someone who has limited depth perception or farsightedness. For someone who already uses a cane for navigation, a specialized all-terrain or "hockey tip" cane can be used to prevent snagging on vegetation or stones. Alternatively, wearable sensor devices can detect obstacles around an individual, using auditory feedback to assist them in navigating an unfamiliar environment. Light level can significantly affect the visual field of some visually impaired individuals, so time of day and the amount of ambient light from foliage or surroundings are important to consider. Color discrimination can be difficult for individuals with different forms of color blindness or vision loss, which may be important to consider depending on the context of the field work (i.e., identification or color discrimination). Specialized glasses can mitigate some, but not all forms of color blindness, and adjusting the light level with head lamps or flood lighting may improve visual acuity for some individuals. Dictation devices for spoken notes and data logging can replace written ones in some cases, and other devices can read text off of pre-printed documents or notes out loud for users.

Deafness and hearing disabilities

A major barrier for deaf or hard of hearing individuals in the field is the effect of ambient noise masking (Korhonen 2021). Wind and other noise outdoors can completely block out other sounds, limiting communication and interfering with research or course participation. Many modern hearing aids and cochlear implants are bluetooth enabled and could be linked to walkie-talkies or headsets. This allows team members or an instructor to speak directly through their hearing devices, completely eliminating background or ambient sound interference. For someone with mild hearing loss or who does not normally wear hearing aids, bone conduction hearing aids, which are marketed for hunting, can help mitigate background noise.

Mobility and physical disabilities

The field environment itself represents the primary barrier for individuals with physical disabilities. Terrain, footing, foliage density, and trekking distances are among many environmental features that may influence whether a particular field setting is accessible or not. For those who use a wheelchair, walker, crutches, or other mobility aids, many field environments can be difficult or impossible to navigate. Most of these devices, particularly those with wheels, are not designed to operate on anything but pavement and indoor surfaces, so grass, sand, snow, or a forest floor can be impassable. Locations with pathways can improve access; however, common pathway materials like gravel are similarly restrictive for standard mobility devices. A diverse range of "off-road" mobility devices are on the market to allow individuals to navigate different terrain types. These include both manual and power wheelchair type devices, as well as "add-on" devices (Fig. 1). Individuals with altered gait patterns, difficult balancing, or poor muscle tone can similarly have a difficult time clearing obstacles and walking on uneven or unstable surfaces like sand. Providing specialized tips to add to canes or crutches for ice, snow, sand, and other challenging terrains can be beneficial and prevent them from getting stuck or slipping while in use.

Fig. 1 Examples of **(A)** a FreeWheel wheelchair attachment (Northpole, United States), which clips to an existing manual wheelchair to improve off-roading ability, **(B)** a GRIT Freedom Chair (GRIT, Medford MA, Unted States), a manual all-terrain wheelchair, and **(C)** an Action Trackchair (Action Trackchair, Marshall MN, United States), a powered all-terrain wheelchair. Photos copyright to FreeWheel, GRIT, and Action Trackchair, respectively.

Invisible disabilities

There are often similarities in the challenges faced by those with visible disabilities and those with invisible disabilites like chronic illnesses, mental health disorders, and neurodivergence (Goodwin 2020; Friedensen et al. 2021). A variety of communication, executive functioning, and cognitive barriers can be addressed through assistive technology; For example, augmentative and alternative communication (AAC) apps can benefit many neurodivergent individuals, and form-based data logging can reduce the pressure of remembering what to record for those with cognitive processing disorders. Similarly, for individuals with dyslexia, dyscalculia, or difficulties with information processing, having a technology-based option for taking notes or performing calculations can reduce stress and improve data quality. People who struggle with fatigue or stamina issues may have difficulties navigating terrain in the field and trekking long distances and may benefit from the same assistive devices as those with many mobility disabilities, or more simple devices like foldable travel chairs.

The ERA model

Overview

The concept for the ERA model is designed to address several of the major barriers to access in field science with an approach that can be easily replicated. A pilot repository was established at the University of Minnesota (UMN) within the College of Biological Sciences in the Fall of 2022 to purchase equipment that would meet the needs of current graduate students with disabilities and test the structure and management of the model. The repository model directly addresses both the lack of general resources for accommodating different types of disabilities in the field and the need for centralized access to adaptive equipment. The information outlined here is meant to serve as a guide or blueprint for others to implement in their own departments or research facilities. This is not intended to be a rulebook, but a starting point from which others can begin to locally improve access to the field.

Management

The establishment of an ERA begins with identifying the specific needs of the given department or college the ERA is serving in an anonymous manner. It should not be assumed that because nobody in the department "looks disabled" or has publicly discussed accessibility needs that nobody would benefit from adaptive equipment or assistive technology in the field. As discussed previously, it is also important to focus on needs rather than diagnoses when selecting equipment to purchase. Conducting an anonymous survey across the department or college that focuses on the specific tasks that individuals struggle with in the field would allow individuals to cite these needs without disclosing their disabilities.

Once items are identified, funding should be secured so the equipment can be purchased. An advantage of the design of this model is that finding funding for equipment can be a collaborative effort and can come from a broader pool of sources than if equipment was purchased on an individual basis. Both internal and external general equipment grants, DEI-centered grants, and infrastructure grants may be potential funding sources for this type of program, and in some cases the purchasing of these devices may be possible to write into research grants. The NSF, for example, offers supplemental funds for specialized equipment to "reduce or remove barriers to participation in research and training by persons with physical disabilities" through its Facilitation Awards for Scientists and Engineers with Disabilites (FASED) program (NSF 2023). The ERA at UMN was established using two internal general equipment grants totaling $10,000. This has allowed for the purchase of an electric and a manual off-road wheelchair, and two off-roading wheelchair add-ons, with plans to purchase additional equipment for other accessibility needs once funding has been secured. If the model is successful, long-term funding could be maintained as part of facilities through indirect costs at a university.

The specific items purchased are up to individual programs, with the ultimate goal of compiling a repository of equipment that is inclusive across a range of disabilites. At the start, focusing funding on equipment that can be used immediately to improve accessibility of existing field research projects or courses is most beneficial, and additional equipment can be purchased once immediate needs are met. For example, if a student in the department could benefit from an off-road mobility device to conduct field work, this could be purchased to establish the repository. Subsequent purchases could then cover equipment not needed immediately, but that would be ready to meet a range of other accessibility needs in the future. The transportation of these devices must also be considered, particularly with mobility aids. The smaller mobility aids can break down into multiple pieces and fit in standard vehicles, while others may require a small trailer or a wheelchair-accessible vehicle to transport, both of which may be able to be loaned from or purchased by the university.

Management of an ERA is expected to vary between universities depending on its size and the scale at which these items are needed. Oversight at a departmental or college level within a university is likely the most practical, however, smaller entities (i.e., individual lab groups) or larger oversight (i.e., the university itself) may also be possible. The long-term management of an ERA generally consists of seeking out additional funding and oversight of equipment care and usage. A protocol for checking equipment in and out will need to be established to keep track of each item and some form of contract to go alongside this could be beneficial in assuring individuals return equipment after use. This could also be attached to the "terms of use" for a given piece of equipment; some of the powered devices, for example, cannot be taken out in the rain, and there are limits on what is considered safe for others. How a damaged or broken piece of equipment is handled must also be taken into consideration, especially given the cost of these devices. These management steps are summarized in Fig. 2.

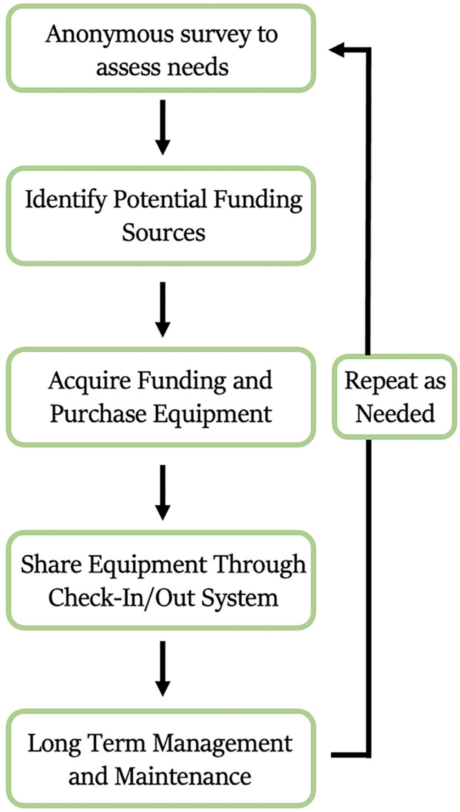

Fig. 2 A flowchart documenting the general process for establishing and maintaining an ERA at a university, beginning with the identification of needs and funding sources, acquiring equipment, overseeing its use and maintenance, and purchasing new equipment as needed.

Benefits

The predominant benefit of the ERA model is that the financial burden of purchasing adaptive equipment for field research or courses is taken off of individuals and instead transfers to a larger entity. With the cost of adaptive devices reaching up to $30,000, the price burden is generally far too great for any one individual to purchase for use in their research, particularly for undergraduate or graduate students. The cost of these devices is also often too high for lab or research department to consider purchasing for the use of one person. The ERA model instead centralizes access to both the funding and the equipment by using a collective pool of resources to purchase equipment for anyone in a department, college, or university to use. A library-type system of adaptive devices would allow researchers and students the opportunity to check items out for classes or research projects without needing to front the cost themselves. An added benefit for those who use mobility aids such as wheelchairs is the opportunity to use ERA equipment in place of their own device while working in the field. These adaptive devices are designed to handle outdoor conditions and with price tags as high as $40,000, avoiding wear on customized mobility device is a significant benefit of having access to the ERA. The models design also standardizes access to equipment outside of the traditional accommodations system. It creates a more uniform system from one university to the next, creating more consistent access to accessible field resources, with the potential for collaboration and equipment sharing between universities. While working alongside existing disability services centers and advertising the availability of this resource within them will certainly be beneficial, operating as an independent entity affords several advantages. The model would not require formal documentation about a disability and could effectively operate on an honor system; this type of equipment realistically would only be sought out by someone who actually needed it. It ensures access to individuals across the academic pipeline, from undergraduate students to faculty, all without requiring formal accommodations. This applies to visiting scholars, temporary employees like field techs, or even just individuals who have been unable to access accommodations for any of the aforementioned reasons. It also provides independence from the bureaucracy of the accommodations process to get equipment to individuals in a timely manner and can operate outside of the normal scope of university accommodations. This means if someone's research takes them out of the state or country, or they are working outside of the school year, they will still have access to the equipment.

Finally, the ERA model can be used as a platform to collect much-needed data in three areas: perceptions of accessibility in field work, representation of disabled scientists in field work, and the effectiveness of adaptive equipment and assistive technology in improving the field work experience of disabled students or researchers. The implementation of surveys before and after field courses and collection of basic demographics from individuals who check out equipment are just a few ways that this model can begin to fill the void of information on access in field science. This is especially true given that the blueprint design of this model can theoretically provide similar models at many universities, and combined data across these can create robust datasets on the state of accessibility and representation in field science.

Broader impacts

When considering the effort required to help make field science more accessible both on an individual basis and by addressing more systemic issues, a common question that may arise is why we should bother: "Wouldn't it be easier to simply have disabled students not participate in field activities, or to encourage a disabled graduate student not to include field components in their research?" In actuality, the ability to participate in field-based science is invaluable and should be an option for anyone, regardless of their physical ability.

Studies have demonstrated that participation in field-based activities boosts retention and narrows achievement gaps, particularly among underrepresented minorities (Beltran et al. 2020). The "hands-on" environment improves learning and retention of material while providing an environment for genuine social interactions, collaborative learning, and the development of a sense of belonging (Theobald et al. 2020; Zavaleta et al. 2020). This is particularly important for disabled students, as they are often more likely to feel isolated in college than able-bodied peers. Access to adaptive equipment provides a holistic route for making courses and research opportunities more inclusive to disabled scientists and breaking down systemic barriers. Making field science more accessible also has important implications in broader DEI efforts. People of color are more likely to be disabled yet less likely to be represented in STEM, and crossover with already reduced representation in the field makes these communities particularly vulnerable to a lack of access (Courtney-Long et al. 2017). The scientific community benefits from the diversity of thought, background, and skill that can only be developed from the lived experiences of a diverse demographic of scientists, which includes disabled individuals. Evidence shows that scientists from underrepresented background have higher innovation rates, and the daily challenges associated with being disabled that require problem-solving and adaptability make disabled scientists an asset to STEM fields (Hofstra et al. 2020; Daehn and Croxson 2021). We can only expect disabled people to come to the table if the table is first made accessible to them.

Ultimately, accessibility in science affects all of us, disabled or not. By making field science more accessible, even able-bodied scientists can benefit through what is called the "curb cut effect." This is the phenomenon in which improving accessibility for disabled individuals has secondary benefits able-bodied people (Belch and Barricelli 2004). The name references the cut outs in sidewalks designed for wheelchair users, but that also happen to help those with strollers or bikes. Accessible field opportunities invite more diverse researchers and facilitate higher quality science by meeting a broader range of needs, and commitment to improved accessibility represents a long-term investment and benefit for the scientific community (Hofstra et al. 2020). This review puts forward the concept of an equipment repository as a pathway for addressing this need for accessibility and improving the representation of disabled scientists in field research. Every able-bodied person is one accident, injury, or illness from becoming disabled, and could someday themselves need accommodations to carry out their own research. Establishing a network of adaptive equipment repositories at major research institutions could serve as a starting ground for fostering a more prepared and accessible future in the realm of field science.

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Data Availability

There is no data associated with the paper.

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