Strategies for change: thriving as an individual with a disabilty in STEMM

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Editor: [Haysetta Shuler]

Abstract

Disability remains an underacknowledged and underdiscussed topic in science, technology, engineering, mathematics, and medicine (STEMM). Social stigma and fear of negative outcomes have resulted in a consistent lack of disclosure. Disabilities cause social and professional difficulties for those that have them. While some faculty can be allies, past literature shows that steps must be taken to make disabilities visible in STEMM at both student and faculty levels. Here, we offer suggestions to better support faculty and students in enhancing the outcomes of individuals who have invisible disabilities. Critically, techniques such as abolishing stigma, universal learning, and better mentoring may improve the challenges faced by those who self-identify as an individual with a disability.

Keywords: STEMM, disability, underrepresented minorities, representation, invisibility, student retention

Introduction

Individuals with a disability in science, technology, engineering, mathematics, and medicine (STEMM) can, over time, develop feelings of isolation. However, those that have an invisible disability will feel the need to hide their disability to succeed or feel accepted in their social and professional environments. While topics such as gender and race are commonly discussed with regard to underrepresented minorities in STEMM, individuals with a disability, despite being the world's largest minority (World Health Organization 2011), Individuals with a disability are often left out of the conversation (Slaton 2013), which can cause feelings of being overlooked and neglected. Here, we define disability based on the description offered by the Measuring Health and Disability in Europe: Supporting Policy Development (MHADIE) consortium: "Disability is a difficulty in functioning at the body, person, or societal levels, in one or more life domains, as experienced by an individual with a health condition in interaction with contextual factors." (Leonardi et al. 2006). Many disabilities, such as autism, dyslexia, chronic fatigue syndrome, and mental illnesses, may not be readily visible. For disabilities that are visible, individuals with a disability may try their best to hide them (Yerbury and Yerbury 2021). While individuals with a disability have valid reasons for avoiding othering themselves, for both invisible and visible dis-

abilities, better services need to be formulated to ensure adequate support is being provided. Here, we advocate for institutions to understand that individuals with a disability have unique talents and the willingness to produce novel, high-quality work. For individuals with a disability who do not wish to disclose, better mechanisms to avoid othering themselves are required. Additionally, the proper support that comes with disclosure is still lacking, indicating multiple measures need to be taken to adequately support students and faculty with a disability. We offer suggestions to increase their involvement and sense of belonging at both the student and faculty-levels in STEMM.

In recent years, the number of self-reported students with a disabilty in higher-education has continued to grow, and is currently at approximately one quarter of all students, yet their graduation rates remain nearly half that of their peers without disabilities (Herbert et al. 2014). However, these lower graduation rates are not from lack of ability. Literature has shown that standardized test scores and achievement of those with learning disabilities remain on par with national averages (Sparks and Lovett 2009). Although graduation and employment rates have improved overall across STEMM, these improvements have been limited for students with a disability and still lag-behind those of students without a disability (Joice and Tetlow 2021). Importantly, recent data

across 10 years from the UK showed that, especially at postgraduate school level, the attrition rate in STEMM fields is higher for students with a disability (Joice and Tetlow 2021). Furthermore, those with disabilities who are leaving STEMM are less likely to be employed afterwards (Joice and Tetlow 2021). This can potentially occur due to individual discouragements such as feeling defined by their disability and a lack of support from mentors to continue in the STEMM fields (Yerbury and Yerbury 2021). In contrast, these adverse feelings may occur from direct bullying or negative relationships or experiences at their institution due to their disability (Yerbury and Yerbury 2021). In any case, we underscore that while marginal improvements have been made in increasing representation for students with a disability, despite adequate performance, students with a disability are still having negative outcomes in STEMM.

If a student with a disability decides to stay in academia as a faculty member, they must endure disparities in accessibility and inclusion that their counterparts without do not. This is only exemplified by the still-lacking representation of faculty with a disability in STEMM. However, this could also be due to a lack of advancement opportunities for faculty with a disability . For example, faculty with a disability are less likely to hold a senior-level faculty position and more likely to have teaching-only contracts (Joice and Tetlow 2021). While many of these issues exist outside of STEMM fields, critically, STEMM fields have a lower percentage of faculty with a disability than observed in non-STEMM fields (Joice and Tetlow 2021). Moreover, while the number of individuals with a disability in the general population increases across age, the reverse is true for the STEMM fields (Careers Research and Advisory Centre 2020). While this may be a matter of employees choosing not to disclose their disability status, it may also be a sign of a leaking pipeline (Hinton Jr et al. 2020a). Faculty with a disabilty leaving STEMM can be particularly harmful, as a much-needed support system for students with a disability can be lost over time. Therefore, institutions must focus on improving their work accessibility and inclusion as a first step in improving the support system for students with a disability.

In combination, these data indicate that disability remains an obstacle in all programs, but especially in STEMM fields. Increasing programmatic opportunities and support for individuals with a disability in STEMM, however, is more complex than simply increasing diversity. Increasing support systems and opportunities, will also increase representation and in turn, increase the innovation and awareness needed to include this group into the academic table of discourse and idea sharing (Daehn and Croxson 2021). Although research on disability in STEMM is especially lacking, studies have confirmed that innovation increases as diversity increases in STEMM (Østergaard et al. 2011, Hofstra et al. 2020). The first step to correcting the issues that individuals with a disability face in STEMM is to evaluate specifically, why individuals with a disability may choose to remain invisible.

Why disability remains invisible: social stigma

Critically, if individuals with a disability feel uncomfortable disclosing their status, this can lead to their further feelings of isolation which increases thier risk of falling out of the STEMM pipeline (Hinton Jr et al. 2020a). Many individuals with a disability elect not to officially report their status to others or the formalized disability office at their institution (Careers Research and Advisory Centre 2020). In some instances, there may be a specific aver-

sion to disclose such as fear of stigma. Current disability services may also fall short. This is illustrated by the fact that graduation and persistence rates were relatively similar between individuals with a disability who utilized college disability support services and those who did not (Herbert et al. 2014). This could be due to things such as complex registration for support programs that are unique for each institution that makes disclosure more cumbersome. Moreover, for disabilities such as mental health conditions, individuals may fear their disability will not be recognized due to varying clinical or social definitions, and documentation requirements. In combination, these reasons have been cited to deter faculty and students from officially registering their disability status.

Social stigma and bullying are also major causes for individuals to avoid disclosure of being an individual with a disability. Many who perform well academically fear that teachers will treat them differently or that their academic performance or social perceptions will be negatively impacted if they decide to disclose (Barnard-Brak et al. 2010). Similarly, students may also fear that if they report their disabilities, it may hold them back from certain opportunities. Even though legal and institutional protections exist, individuals fear that their disability may hold them back from being selected for certain classes or opportunities (Careers Research and Advisory Centre 2020). For students that are bullied, they can begin to believe the negative things people say about them. Specifically, the lack of support from institutions and many abled colleagues, may cause individuals with a disability to tell themselves that praise received for their success is about their disability status, and take away from their feelings of resilience over obstacles that they have conquered. This can easily lead to feelings of imposter syndrome, a condition in which one feels that their accomplishments were not truly earned (Hinton Jr et al. 2020b). For many individuals with a disability, it can feel easier to hide their disability than to be forced to continuously justify it.

Intimidation and fear of gaining autonomy are also lingering issues. For example, while some faculty can be very accommodating, this is not always the case. Literature has found that the majority of students with a disability report at least one experience in which faculty did not honor accommodation requests (Barnard-Brak et al. 2010). Even more alarming, only 1 in 10 of these students actually report the faculty for their blatant discrimination (Barnard-Brak et al. 2010). It can be scary to report someone who is responsible for one's academic future, and this can be an unreasonable request for students to do themselves. Furthermore, formally registering with the disability office is equivalent to "othering" oneself. As soon as they do this, they instantly feel they are different from other people, which can be a scary prospect for students and faculty with a disability alike. Regardless of the reason for avoiding disclosure, faculty are especially unlikely to report their disability both officially and socially (Bettencourt et al. 2018). If faculty are avoidant to disclose, this can cause a ripple effect in which students with a disability are unable to find the support resources they need. Importantly, faculty can serve as mentors and allies with similar life experiences if they gain the resources and encouragement to disclose their disability statuses. This is because they have already successfully navigated being a student with a disabiltiy themselves and can teach students powerful techniques to succeed as a minority scientist, such as avoiding microaggressions, knowing one's limit, and the power of saying "no," (Hinton et al. 2020, Hinton Jr et al. 2020b, Marshall et al. 2021). Some individuals may want to keep their disability hidden, which remains valid; however, institutions must make changes so individuals will not feel like they are setting themselves back by

choosing to disclose. In combination, support strategies such as affinity groups must be developed for bothstudents and faculty with a disabilty, so they feel more comfortable disclosing their disabilities and have more of an incentive to do so.

It should be noted that although some disabilities can include life-altering things such as paralysis, other disabilities are not readily noticeable (Table 1) (Joice and Tetlow 2021). This can be detrimental when stigma surrounding certain invisible disabilities, such as those that affect mental health, may prevent individuals from seeking much needed treatment. Importantly, this calls for systemic education on the awareness and acceptance of all invisible disabilities.

Table 1

Strategies to support students with a disability

For students, barriers must be broken down at both the institutional and the individual levels to ensure everybody is on the same playing field (Fig. 1). Many labs, classes, and other areas are still incompatible with certain disabilities. Breaking exclusive barriers can be done by a shift in universal design and ergonomics of institutional facilities. Rather than teach and lecture in a format that will help the majority learn, lectures can be in a format that helps the minority learn as well. For example, institutions can make standardized power point presentations that are disability friendly with guidance from students and faculty with a disability. While the implementation of this design would help students with a disability to learn inclusively, importantly, it would not hinder students without a disability from learning the same material. Better coaching for faculty in teaching using a universal design is paramount. Many students with a disability, discuss their positive experiences with faculty as a highlight in disability services (Barnard-Brak et al. 2010). However, this is just a starting point. Notably, all faculty should be able to create an accommodating teaching design to provide optimal learning experiences for all students. While the Covid-19 pandemic had numerous negative effects in teaching and learning, some of the lessons learned in the switch to online learning may be retained as we all approach new pedagogy styles and techniques. Specifically, for students with learning disabilities, techniques used such as take-home tests and video modeling can be incredibly helpful (Wright et al. 2020). However, there is still a lack of accessible technologies at many universities, which means that even these methods can cause difficulties for some students. In-person classes and labs should be adjusted to increase involvement for individuals with a disability. Past literature has created numerous suggestions to make labs more accessible through methods such as sensor activated sinks, accessible eye wash stations, and weighted bases for microscopes (Prema and Dhand 2019). Universal design for learning, although it has been a growing movement, has not been implemented at most universities (Slaton 2013).

Institutions need to adapt using several possible methods. The first of which should be universal instruction and training for faculty on how to better help students with a disability. It is often left to the discretion of faculty to deal with accommodations. This results in the quality of accommodations being heavily varied in the levels of care provided. This is an unfortunate issue because it is still common for some faculty to be misinformed about the purpose and legality of accomodations (Bettencourt et al. 2018). Furthermore, individuals with a disability may not disclose their disabilities for fear that others will misconstrue or perceive that their approved accommodations is "cheating" rather than simply helping everyone get to the same starting line. The responsibility rests on institutions to provide more education about why these accommodations are necessary and equitable, along with no-tolerance policies being implemented for bullying and non-compliance.

Faculty often report having a tough time accommodating for different courses and disability types (Bettencourt et al. 2018). This could also be a cause for the large variation reported by students in satisfaction for accommodations (Barnard-Brak et al. 2010), in which some professors can be very helpful while others may be discriminatory. Creating clear guidelines and alternatives for all professors and enforcing approved accommodations for students with a disability can be the first step to reducing this burden. Therefore, there should be minimum standard accommodations provided, depending on disability types, that the institution verifies are being met. This will formulate a system in place to follow up with professors at an institutional-level and ensure they are adequately working with students and their respective disability offices. Furthermore, there should also be institutional policy for faculty in which they provide validation that they are providing inclusive teaching and taking steps to help students with a disability. Currently, much of the tension of confronting nonaccommodating professors is placed on the students who are responsible for reporting professors who are not adequately accommodating them. Encouraging students to complete anonymous evaluations of their professors and of their learning environments is one way to alleviate this burden on students. Any lessoning of their load, especially with advocacy and holding those who do not comply with legal accommodations accountable, would result in more positive outcomes and overall awareness for the plights that students with a disability encounter.

For students who wish to disclose, institutions must also provide clearer definitions of disability and detailed information about why and how to register with the disability service office. Most institutional systems require individuals to seek disability services out themselves, and this may be awkward. It requires proof of proper diagnosis to get a letter of recommended accommodations, which can be a tedious process and turn students off, especially if the benefits do not outweigh the costs (Barnard-Brak et al. 2010). Reducing the barriers to initiate interactions with disability services is paramount. This can include having automatically scheduled meetings with the disability office once a student has registered and indicated that they have a disability; therefore, students do not need to go out of their way to make them. Another critical factor in allowing disability offices to be more effective is much needed budget increases. This is especially pertinent for rural or small institutions (Vincent and Chiwandire 2019, Kim 2022), who often have too small of a budget dedicated to disability services to function properly. While budgets will vary, the average total budget of disability offices in the USA is approximately $ 250,000 (Dolmage 2017), and a previous survey found that approximately a quarter of disability offices had an annual operating budget under $ 10,000 (Linder et al. 2015). This can result in inadequate staff training. For example, a recent study of disability offices in the USA found that nearly 80% of staff had no training in autism, despite approximately 50% of that same population working in disability offices for over 5 years (Kim 2022). Therefore, reducing the barriers around accessing disability services, increasing ease of disclosure, and increasing the budgets of disability services will not only be beneficial for the individual, but for advancing accessibility across the institution.

Table 1 Common Types of Disabilities and Examples of Ways to Support Them

Type of Disability	Methods to Support Them
Deaf or hard of hearing	-Offer clear notes prior to lab meetings so they may read them during and ahead of time
	-Avoid discussing in large areas which can be difficult for hearing
Vision Impairment	-Avoid non-verbal cues
	-Allow the trainee preferential seating, ensure there is universal design both in the labortaory and overall institution
	-Invest in speech-to-text software and other resources necessary for their research and writing
Mental Health Conditions	-Connecting them with institutional resources for therapy or other mindful resources
	-Being mindful of mental health breaks and ensure they feel the option to take them as necessary
Physical/Mobility Disabilities	-Universal asscesible design at both institution and the laboratory
	-Assistant or laboratory member to aid in laboratory techniques they are not able to perform
Learning Disabilities	-Offering additional hands-on time during laboratory meetings or adapting conversating style according to individual's needs
	-Provide intentional mentoring to ensure there are clear and realistic time schedules which are appropriate for mutual needs
	-Cultural-humility trainings across the institution to reduce potential biases, especially for invisible learning disabilites
Medical Disabilities	-Laboratory time-schedules to allow for time dedicated to any doctor's appointment's necessary
	-Individual Development Plan (IDP) to create a reasonable plan and timeline for individual
Speech and Developmental Disabilities	-Mentoring in how to thrive in science with a disability
	-Cultural-humility trainings across the institution to reduce potential biases, especially for invisible developmental disabilites

Additionally, scholarships, internships, and research opportunities specifically for those with a disability can be vital given the adversity and difficult outcomes that they often face. While in countries such as the UK students with a disability are given extra financial help, which is paid on top of the regular aid package and is not considered a loan, funding for individuals with disabilities is still lacking in many countries, including the USA (Vincent and Chiwandire 2019). More opportunities need to be offered, specifically for individuals with a disability , in STEMM. This can be through grants and other CV-improving activities that can give them hands-on experience that they might not gain otherwise.

Peer mentors can also be important in identity affirmation and encouraging disclosure by seeing other individuals with a disability facing and overcoming similar situations. Furthermore, faculty mentors with a disability can serve as a support pillar to help guide students. However, this will require greater disability self-disclosure by faculty. One way that may remove some of the stigma around disabilities are utilizing social media to display that scientists with disabilities are able to make it in academia. Thus, individuals can feel as though they have the ability to disclose and not be looked negatively down on, and they can use social media to connect to other mentors who may have disclosed there disability. In general, there is a lack of faculty with a disability mentors due to lack of appropriate accommodations and stigma around disclosure. This can be such a burden that they will often hide their disability from their peers and students. Importantly, workshops and training seminars to formally establish the importance of support for faculty with a disability can be vital in changing the disability landscape in STEMM. It will provide important opportunities for faculty openness in supportive environments and in turn, those faculty can help other students feel more comfortable with disclosure. Another method to address these issues is

having smaller classrooms and class sizes to allow for more personalized attention (Bettencourt et al. 2018). This can result in more transparent faculty interactions as they can share experiences with students easier, as well as students with a disability receiving more individualized help. It is important to mention that while student support is more often discussed in comparison to support for faculty with a disability , the needs of such faculty should not be overlooked when considering appropriate support systems to build.

Perhaps one of the best ways to lessen disability discrimination for both faculty and students is to require institution-wide cultural humility training in disabilities. Cultural humility occurs when an individual gains knowledge about other cultural identities, ideologies, and beliefs that differ from their own through self-evaluation and reflection (Murray et al. 2022b). Providing adequate exposure of the culture and beliefs of the community with a disability is vital for fostering empathy and gaining an understanding of what it is like to live with a disability (Murray et al. 2022b). This is crucial considering that many faculty and students do not know what it is like to learn and be in an environment that does not consider their existence, let alone their daily struggles. This can be supplemented by first-hand experiences from those with disabilities. For example, many autism spectrum students (ASD) are extremely sensitive to the pitch and the complexity of sounds. If a student is typing loud or tapping their fingernails on a desk across the room while the ASD student is trying to listen to the lecture, it can cause sensory overloads that are very difficult to recover from and may overstimulate and hinder the student's functioning and attention span for the rest of the day. Another example could be the lack of an accessible ramp to a building or lab that impedes students or faculty in wheelchairs from those environments completely. These are just some examples of things

Figure 1. Visual representation showing the importance of equity and equality, as an attempt to get everyone to the same starting line with relatively equal footing.

that people who do not have disabilities do not need to consider or acknowledge in their daily lives that highly affects the lives of individuals with a disability . Furthermore, providing cultural humility training would not only raise awareness about the issues that faculty with a disability and students face daily, it would also increase empathy which enhances an inclusive environemnt without disclosure being a necessity (Murray et al. 2022b).

As it has been previously stated, the value of mentorship, especially for minority students, is crucial. This is especially true in STEMM as minorities are markedly susceptible to the sometimes-harsh scientific environment (Hinton Jr et al. 2020b). These mentor–mentee relationships can be casual or intentional (Shuler et al. 2021, Uddin and De Los Reyes 2021, Stuchiner et al. 2022). Casual mentoring is less formal than intentional mentoring and is generally more honest and transparent (Uddin and De Los Reyes 2021, De Lora et al. 2022). Intentional mentoring involves providing informed decisions that will meet and honor the mutually established goals of the mentor/mentee relationship (Murray et al. 2022b). Another aspect that a mentor and mentee should consider is taking on multiple mentors to ensure individuals with a disability are getting the network that they need, which is of vital importance (Marshall et al. 2022). This is critical for those in multiple minority groups. For example, if a student with a disability has a mentor that shares a common disability with them but is not in their field or who is not of the same racial/ethnic background, multiple mentors would be critical in ensuring that a holistic network is established. Part of this should include required cultural humility training for mentors so that they could better embrace and be able to effectively interact with individuals with disabilities (Murray et al. 2022b, c).

Mentors can help trainees with a disability in several ways. As great mentors give rise to great leaders, the types and quality of the mentorship provided is paramount. This is especially true considering that students with a disability will be the next mentor with a disability . In fostering this, students with a disability could be given leadership roles. This would not only prepare them for future mentorship roles, but it would also give them shared leadership experiences that rely on the input of a team versus one individual (Whittaker and Montgomery 2022). Also, while some individuals with a disability may have difficulty working in a team, providing them new roles such as leadership roles may offer them a chance to flourish. Beyond this, mentors can aid students by ensuring equality in treatment and networks to succeed. This can include giving individuals with a disability the power to say no and avoid limiting them and give them the power not to be forced to do things they do not want to do (Hinton et al. 2020). Finally, mentors should also consider that each disability is unique. Time management plans and individual development plans (IDPs) to tailor time planning are important for each individual, and mentors should adjust their styles to help individuals with a disability

make these (Murray et al. 2022a). IDPs may be especially helpful in creating a structure and clear set of goals for each individual's unique needs. In combination, institutions and mentors can provide valuable sources of aid for students with a disability (Table 1).

Strategies to support faculty with a disability

While many strategies to support individuals with a disability focus on students, faculty with a disability can often have similarly large struggles that often go unnoticed (Yerbury and Yerbury 2021). Past research has found that faculty have little belief that formally reporting their disability status would be beneficial (Careers Research and Advisory Centre 2020). Importantly, this can cause issues as it can create invisibility in the field, and a lack of representation may deter younger minority scientists from pursuing a career in STEMM. To begin, there needs to be better reasons to encourage faculty to disclose their disability status. Many do not understand who at the institutional level has access to disclosures and what the benefits of disclosing can be. Therefore, it is imperative for the benefits of disclosure to be more clearly communicated. Importantly, research funding institutions and benefactors need to increase ability for individuals with a disability to thrive and provide clear definitions of what qualifies as an individual with a disability when applying for minority funding.

Funding is a large aspect of many labs and currently the additional avenues to gain funding as a individual with a disability remain limited (Bettencourt et al. 2018). This means there must be a proactive shift in academia to provide support in ensuring equitable research can be performed, adequate adjustments are made, and increased avenues for funding are available. During these transitions, it is important to remember that disability is not a one-size-fits-all model. While some individuals with a disability and institutions can have many positive reactions (Yerbury and Yerbury 2021), others have reported detrimental effects (Careers Research and Advisory Centre 2020). Therefore, these changes must vary from individual to individual. At an institutional level, this means not just creating minimum support standards and standardized disability definitions, but also bolstering disability services that can adapt to individual faculty needs. Unfortunately, many of the issues which inhibit minority participation go much deeper and are more complex than the scope of this article.

The current way that many labs in STEMM fields operate runs contrary to the changes needed to increase accessibility, which is vital. For example, many wet-labs, may have long and inflexible working hours in addition to a constant physical activity requirements. This can make STEMM fields too demanding, especially for those with physical disabilities. Given that most labs do not have easy mechanisms to avoid certain physical activities, individuals with a disability may be forced to disclose if they need accommodations. Furthermore, the poor work–life balance associated with academia, especially at the postdoc level (Mo 2020), can be an added challenge for faculty with a disability. Women with a disability can be put at a further disadvantage as past results have shown that women, due to other responsibilities and difficulties in advancing in academia, have poorer work life balance (Drew and Marshall 2020). Therefore, it may be important to encourage a more positive work–life balance.

Faculty with a disability may decide to serve as pillars and mentors with similar lifepaths for students with a disability . For faculty who serve as important mentors for students with a disabil-

ity , it can negatively impact their careers. Most funding is based on productivity of the lab, which discourages mentoring as time, when funded, could be better spent on research. Importantly, for mentors with a disability , who already have the aforementioned hindrances, the time necessary to devote toward mentoring students might not exist. Having mentors with similar life-identities can be critical for effective mentoring (McGee 2020). However, current systems in STEMM seem to deemphasize this and may neglect to value other important duties outside of research. Therefore, there needs to be formalized ways to recognize the mentoring efforts of mentors with a disability . In the future, however, many more changes will need to be made.

Conclusion

Methods to help individuals with a disability in STEMM, remain lacking. Critically, more research is needed to understand effective strategies to aid those with disabilities in all career levels and expand the current literature. When it comes to inclusivity, rarely is science utilized, which is a restrictive weakness. Taking approaches to quantitatively measure whether certain strategies make impactful differences or not can be important to do in tandem with more qualitative approaches. Finally, it is also important to involve people with disabilities into conversations about reforming environments and equity. While institutions may be striving for welcoming environments, these changes will not be effective if they do not make a difference to improve the lives of those who need them. Past literature has shown how those with disabilities feel as though their voices are not heard (Careers Research and Advisory Centre 2020). This is an issue and institutional disability offices should have faculty members with a disability sit in on board meetings in supplementary paid positions, so better insight may be offered. While individual change can be paramount in altering diversity attitudes, ultimately institutions can affect larger strides towards mending issues for faculty and students with a disability .

When considering and discussing disability, individuals with a disability do not exist in a vacuum. Many of them also have other life circumstances, which further pose difficulties in staying in the STEMM pipeline, such as lower socioeconomic status, or being an underrepresented minority (Hinton Jr et al. 2020a). Therefore, services for individuals with a disability are critical to begin to equalize conditions (Fig. 1). Past research has shown that ethnic minorities who have a disability have a lower retention rate than their counterparts without a disability (da Silva Cardoso et al. 2013). Therefore, many individuals with a disability in STEMM can be invisible for multiple reasons. The invisibility of students and employees with a disability in STEMM may not be simply due to the lack of participation, but also from individuals with a disability actively making themselves invisible. However, current funding mechanisms are inadequate and limit disability offices of the vital funding needed to ensure accomodation needs are met properly. Research, for good reason, typically focuses on increasing racial and ethnicity participation in STEMM, but much qualitative and quantitative research is still lacking regarding individuals with a disability. Past literature has noted that it seems as though many scholars are hesitant to engage in research on disabilities and the reasons these barriers still exist for individuals with a disability (Slaton 2013).

To create positive change in working toward fixing the invisibility of disabilities in STEMM, it must be addressed at every level. There must be a call for students to ask for help if disability offices or faculty are not adequately supplying the appropriate accom-

modations or assistive technologies. Disability offices are there to evolve and students should utilize them. Similarly, students should take a stand against choices being made that will negatively impact individuals with disabilities. For abled individuals, this may also include taking a stand for students who may not wish to disclose themselves as an individual with a disability. Faculty should serve as mentors and as support pillars for students with a disability . This can be especially important for minority students (Hinton Jr et al. 2020b). Faculty must actively work to correct bigoted views from themselves and those around them. Institutions must provide instruction to all faculty and seek to take advanced steps against discrimination. Importantly, institutions must take steps to truly be inclusive as opposed to just saying that they are inclusive to be politically correct. Fundamentally, this includes increasing budgets of disability offices, especially rural ones, so they can provide better institution-wide education about disabilities and provide aid to students who choose to disclose. In combination, these steps can begin the process of allowing individuals with a disability to get the support they need and deserve to thrive in STEMM.

Definitions and Resources

Disability

A disability is a physical or mental condition that substantially affects one or more major life activities.

Major Life Activities: The term "major life activities" refers to normal functions such as caring for one's self, performing manual tasks, walking, seeing, hearing, speaking, breathing, learning, and working.

Physical conditions include any physiological disorder or condition, cosmetic disfigurement, or anatomical loss limiting one or more of the following bodily systems: neurological, musculoskeletal, respiratory, cardiovascular, reproductive, digestive, skin, endocrine, etc.

Mental conditions include any mental or psychological disorder that impacts behavior, emotional regulation, or cognition. Examples of metnal conditions are: organic brain syndrome, depression, anxiety, and neurodevelopmental conditions such as Autism.

A learning disability is a generic term that refers to a group of conditions characterized by significant difficulties in the use of listening, speaking, reading, writing, reasoning, or mathematical abilities.

The Americans with Disabilities Act

The Americans with Disabilities Act of 1990 or ADA (42 U.S.C. § 12101) is a civil rights law that prohibits discrimination based on disability. It affords similar protections against discrimination to Americans with disabilities as the Civil Rights Act of 1964 , which made discrimination based on race , religion , sex , national origin , and other characteristics illegal, and later, sexual orientation was added to the amendment.

Reasonable Accomodations

What is a reasonable accommodation? A reasonable accommodation is a modification or adjustment to a course, program, service, job, activity, environment, or facility that enables a qualified individual with a disability to have an equal opportunity to attain the same level of performance or to enjoy equal benefits and privileges available to an individual without a disability. Some common academic accommodations include extra time on tests, use of peer note takers, use of computers for note taking, and provision of sign language interpreters.
https://www.washington.edu/doit/strategies-working-people-who-have-disabilities

Access/Disability Services and Requesting Accomodations

https://www.vanderbilt.edu/eoa/disability_services/

https://www.vanderbilt.edu/eoa/about/

https://www.vanderbilt.edu/eoa/disability_services/FAQs.php

Other Definitions and Terms

Covid-19: Coronavirus 2019

CV: curriculum vitae; a condensed written summary of an individual's education, career experience, and qualifications.

Intentional mentoring: providing informed decisions that will meet and honor the mutually established goals of the mentor/mentee relationship.

Casual mentoring: less formal than intentional mentoring; generally, more honest and transparent mentor–mentee relationships.

Othering: the perspective and/or treatment of an individual or group of people that are intrinsically different than oneself.

STEMM: science, technology, engineering, mathematics, and medicine.

Additional Resources

https://www.ada.gov/

https://www.dol.gov/general/topic/disability/ada

https://www.eeoc.gov/laws/guidance/fact-sheet-disability-discrimination

References

Barnard-Brak L, Lechtenberger D, Lan WY. Accommodation strategies of college students with disabilities. *Qual Rep* 2010;**15**:411–29.

Bettencourt G, Kimball E, Wells R. Disability in postsecondary STEM learning environments: what faculty focus groups reveal about definitions and obstacles to effective support. *J Postsecon Educ Disabil* 2018;**31**:383–96.

Careers Research and Advisory Centre (CRAC). Qualitative research on barriers to progression of disabled scientists. Cambridge: Careers Research and Advisory Centre (CRAC), 2020:80.

da Silva Cardoso E, Dutta A, Chiu C-Y *et al.* Social-cognitive predictors of STEM career interests and goal persistence in college students

with disabilities from racial and ethnic minority backgrounds. *Rehabil Res Pol Educ* 2013;**27**:271–84.

Daehn IS, Croxson PL. Disability innovation strengthens STEM. *Science* 2021;**373**:1097–9.

De Lora JA, Hinton A, Termini CM. Creating inclusive environments in cell biology by casual mentoring. *Trends Cell Biol* 2022;**32**:725–8.

Dolmage JT. *Academic Ableism: Disability and Higher Education*. Ann Arbor: University of Michigan Press, 2017.

Drew E, Marshall C. Work-life balance in academia: myth or reality?. In: *The Gender-Sensitive University*. London: Routledge, 2020, 52–66.

Herbert J, Welsh W, Hong B *et al.* Persistence and graduation of college students seeking disability support services. *J Rehabil* 2014;**80**:22–32.

Hinton AO, Termini CM, Spencer EC *et al.* Patching the leaks: revitalizing and reimagining the STEM pipeline. *Cell* 2020a;**183**:568–75.

Hinton AO, Vue Z, Termini CM *et al.* Mentoring minority trainees: minorities in academia face specific challenges that mentors should address to instill confidence. *EMBO Reports* 2020b;**21**:e51269.

Hinton AO, McReynolds MR, Martinez D *et al.* The power of saying no. *EMBO Rep* 2020;**21**:e50918.

Hofstra B, Kulkarni VV, Galvez SM-N *et al.* The diversity–innovation paradox in science. *Proc Natl Acad Sci* 2020;**117**:9284–91.

Joice W, Tetlow A. *Disability STEM Data for Students and Academic Staff in Higher Education 2007-08 to 2018-19*. London: Royal Society, 2021, 36.

Kim SY. College disability service office staff members' autism attitudes and knowledge. *Remed Spec Educ* 2022;**43**:15–26.

Leonardi M, Bickenbach J, Ustun TB *et al.* The definition of disability: what is in a name?. *The Lancet* 2006;**368**:1219–21.

Linder KE, Fontaine-Rainen DL, Behling K. Whose job is it? Key challenges and future directions for online accessibility in US institutions of higher education. *Open Learn* 2015;**30**:21–34.

McGee E. Mentoring underrepresented students in STEMM: a survey and discussion. In: *The Science of Effective Mentorship in STEMM*. Washington: National Academies Press, 2020.

Marshall A, Pack AD, Owusu SA *et al.* Responding and navigating racialized microaggressions in STEM. *Pathog Dis* 2021;**79**:ftab027.

Marshall AG, Brady LJ, Palavicino-Maggio CB *et al.* The importance of mentors and how to handle more than one mentor. *Pathog Dis* 2022;**80**:ftac011.

Mo M. Postdocs under pressure:'Can i even do this any more?'. *Nature* 2020;**587**:689–92.

Murray SA, Davis J, Shuler HD *et al.* Time management for STEMM students during the continuing pandemic. *Trends Biochem Sci* 2022a;**47**:279–83.

Murray SA, Hinton A, Spencer EC. Developing cultural humility in immunology and STEMM mentoring. *Trends Immunol* 2022b;**43**:259–61.

Murray SA, Shuler H, Spencer EC *et al.* Mentoring future science leaders to thrive. *Trends Pharmacol Sci* 2022c;**43**:457–60.

Østergaard CR, Timmermans B, Kristinsson K. Does a different view create something new? The effect of employee diversity on innovation. *Res Pol* 2011;**40**:500–9.

Prema D, Dhand R. Inclusion and accessibility in STEM education: navigating the duty to accommodate and disability rights. *Canad J Disabil Stud* 2019;**8**:121–41.

Shuler H, Cazares V, Marshall A *et al.* Intentional mentoring: maximizing the impact of underrepresented future scientists in the 21st century. *Pathog Dis* 2021;**79**:ftab038.

Slaton AE. Body? What body? Considering ability and disability in STEM disciplines. In: *Proceedings of the 120 ASEE Annual Conference and Exposition*. Atlanta, GA: American Society for Engineering Education, 2013. 23.247.1-23.247.16.

Sparks RL, Lovett BJ. College students with learning disability diagnoses: who are they and how do they perform?. *J Learn Disabil* 2009;**42**:494–510.

Stuchiner ER, Lin Hunter DE, Neuwald JL *et al.* Intentional mentoring should increase inclusivity in ecology. *Ecosphere* 2022;**13**:e3902.

Uddin LQ, De Los Reyes A. Cultivating allyship through casual mentoring to promote diversity. *Trends Cognit Sci* 2021;**25**:813–5.

Vincent L, Chiwandire D. Funding and inclusion in higher education institutions for students with disabilities. *Afr J Disabil* 2019;**8**:1–12.

Whittaker JA, Montgomery BL. Advancing a cultural change agenda in higher education: issues and values related to reimagining academic leadership. *Discov Sustain* 2022;**3**:10.

World Health Organization. *World Report on Disability*. Geneva: World Health Organization, 2011, 350.

Wright JC, Knight VF, Barton EE. A review of video modeling to teach STEM to students with autism and intellectual disability. *Res Autism Spectr Disord* 2020;**70**: 101476.

Yerbury JJ, Yerbury RM. Disabled in academia: to be or not to be, that is the question. *Trends Neurosci* 2021;**44**: 507–9.