Examining physicists' perspectives of career viability and knowledge of impairment

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Physics mentors play an important role in supporting students in postsecondary education and in their transition to graduate school and careers. The knowledge and beliefs physics mentors have about disability can affect how they mentor students with disabilities. We administered the Disability and Physics Careers Survey (DPCS) to 237 practicing physicists recruited through physics-specific listservs to measure their knowledge about disability and beliefs about the viability of physics careers for people with different disability diagnoses. This study compares practicing physicists' varied knowledge about different categories of impairments and diagnoses, and their beliefs about the viability of future careers for students with specific impairments. We present our findings examining the knowledge of practicing physicists about disability, their beliefs about the viability of certain physics careers for people with disabilities, and how those beliefs may vary depending on their personal disability experience.

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I. INTRODUCTION

Students with disabilities are enrolling in postsecondary education at increasing rates, and approximately 20% of the current postsecondary student body in the U.S. are students who identify with a disability [1, 2]. However, studies show that STEM professionals hold more negative views about disability than peers in other disciplines [3]. Often, academics and researchers attempt to support marginalized communities by surveying and gathering data about their experiences within the university setting. These methods can burden the marginalized group with additional surveillance and time commitment necessary for the research, as well as result in a deficit view of the marginalized group by exploring why individuals struggle within a system [4].

This study attempts to shift the academic gaze away from a marginalized community to instead research the dominant groups and structures within academia. Using the Disability and Physics Career Survey (DPCS), we gathered data about practicing physicists' knowledge about disability and their beliefs about the viability of physics careers for people with different disability diagnoses. Finally, we explored whether physicists' beliefs about career viability differed across their personal experience with disability.

II. POSITIONALITY AND LANGUAGE

Our social identities and experiences impact how we conduct research and are important to explicate, especially when researching marginalized communities [5]. All members of the author team identify as white, two authors identify as cisgender women, and one identifies as a queer cisgender man. All three authors are diagnosed with anxiety and depression; one author each identifies with degenerative hearing loss, migraines, and obsessive-compulsive tendencies. We acknowledge these identities to both inform and interrogate our interpretations.

While person-first (e.g., "person with disability") and disability-first (e.g., "disabled person") language are both used in disability communities, usage varies by context and person [6, 7]. The first author's preferred identity label is Dis., due to its separation of the concept of ability from the author's identity. However, the survey used in this study was developed by the second and third authors before the first author joined the research team; initially, we selected person-first language because we thought it would be understandable to practicing physicists with varied levels of experience with disability.

III. METHODS

The DPCS is a multi-part survey designed to examine practicing physicists' knowledge and beliefs about disability as well as their beliefs about the impact of disability on the viability of physics careers. The first section of the survey is intended to explore whether participants can place specific diagnoses into the relevant categories of impairment [8]. The research team reviewed relevant literature [9] and assigned each diagnosis (with one exception, traumatic brain injury [10]) to a single category of impairment. However, participants were given the option to choose more than one category of impairment for each diagnosis. The categories of impairment are a combination of categories from similar studies [11], literature about characterizing dimensions of ability [9], and categories used by the National Science Foundation (NSF): physical/mobility, health, cognitive, hearing, visual, and emotional/mental health. The second section of the DPCS explores participants' beliefs about the viability of physics careers for people with a variety of disability diagnoses. Participants were given a series of diagnoses and asked to choose which careers were viable for a person with that diagnosis.

The development of the DPCS was initially reported in a previous study [9]. Three types of changes were made to the version of the DPCS administered to participants in this study. First, we reduced the number of diagnoses from 28 to 14 to shorten the survey and focus on common disabilities in the physics community. Second, we revised the categories of impairment [9]. Specifically, the physical and mobility categories were merged to one category (physical/mobility) since participants frequently conflated these categories and the variation across the categories is small compared to the variation within each category. Additionally, the learning/reading category was merged with the cognitive impairment category as learning/reading impairments are a sub-type of cognitive impairments. Third, we used the open-ended participant responses of physics careers from the pilot version of the DPCS to create closed-response career response options for the current version (see Section V.B.).

We recruited participants by email through physics-specific professional society listservs. We received 237 complete responses from practicing physicists (after removing participants who did not pass the attention check). Table I displays demographics for the participants.

IV. FINDINGS AND DISCUSSION

A. Knowledge about disability

Table II displays the categories of impairment in which participants placed 11 of the given diagnoses. The gray

Table I. Participant demographics.

Gender	Male: 66%, Female: 30%, Non-Binary: 1%, Preferred Not to Answer: 2%
Race/ Ethnicity	American Indian/Alaskan Native: 1%, Asian: 8%, Black: 1%, Hispanic/Latino: 6%, Native Hawaiian/Pacific Islander: 1%, White: 77%, Preferred Not to Answer: 9%, Self-Described: 4%
Disability Experience	Has a Disability: 24%, Has a Peer with a Disability: 68%, No Experience: 8%

TABLE II: Percentage of participants who selected each category of impairment(s) for specific diagnoses. Dark green shading denotes researcher designated categories for each impairment

Diagnosis	V	C	Hl	P/M	E/MH	C+Hl	U	RDC+Hl	RDC+EMH	RDC+C	RDC+Other
Dyslexia	8	59	1	0.5			5	1	4		19
ASD		27	1		24		8	1	26		9.5
ADHD		34	2		24		7	0.5	21		10
LD	0.5	68	0.5		3		4	2	15		6
TBI		20	9		1	6	8		17		39
Lupus			0.5	54	5			19		0.5	0
Paralysis			0.5	69			0.5	16	4	0	10
MS			19	33		0.5	4	30	1	1	13
Anxiety		2	0.5		67	1	1	11		10	7
Depression		0.5			70	0.5		7		10	12
PTSD		1			63		3	6		15	11.5

Hr: hearing; P/M: physical/mobility; Hl: health; C: cognitive; E/MH: emotional/mental health; V: visual; C + Hl: cognitive + health; U: unsure; RDC: researcher designated category

shading indicates the most relevant category for each diagnosis as determined by our research team. Participants consistently placed diagnoses into the appropriate category (i.e., 80% or more) for deafness (88%), blindness (85%), and colorblindness (90%), so these diagnoses were omitted from the table. Prior work [9] found similar trends that practicing physicists place hearing and visual impairments in the most relevant category.

As shown in Table II, more than 60% of participants placed several diagnoses in the same relevant impairment category as the research team, including paralysis (69%), anxiety (67%), depression (70%), post-traumatic stress disorder (PTSD; 63%), and learning disability (LD; 68%). Some diagnoses were infrequently (less than 35%) placed in the same category of impairment by participants and the research team, including autism spectrum disorder (27%), attention deficit-hyperactivity disorder (ADHD; 34%), multiple sclerosis (MS; 33%), and traumatic brain injury (TBI; 35%).

A common trend was that participants selected the same category of impairment as the research team plus the health and/or emotional/mental health category. For example, prior work [9] found participants placed depression and anxiety in the emotional/mental health category of impairment, which is in line with the research team's placement. However, in this study participants were able to select more than one category of impairment for each diagnosis, and we find that more than 25% of participants placed depression, anxiety and PTSD in emotional/mental health in addition to other impairment categories, frequently cognitive and/or health. On the other hand, while participants infrequently placed autism and ADHD in just the cognitive category (aligned with the research team's interpretation), participants frequently placed these diagnoses in both cognitive and emotional/mental health. Participants also frequently selected both physical/mobility and health for paralysis and multiple sclerosis. Thus, with this new response format where participants were able to select multiple categories of impairment, we notice a trend of participants associating an impairment with the same category as the research team plus additional categories of impairment.

We interpret the lower percentage of relevant categorization of the health, physical/mobility, cognitive and emotional/mental health impairments to indicate two things. First, practicing physicists do not have a deep understanding of some of the common impairments experienced by physics students and early career physicists. For example, a recent study found that 16.4% of responding physics students identified with a disability or impairment; of these students, 48% identified with ADHD, 31% with anxiety, 27% with depression, 10% with autism spectrum disorder, and 10% with a specific learning disability [12]. Other research has shown that 50% of PhD students report experiencing anxiety and/or depression [14]. These are the same diagnoses that participants often conflated with cognitive and emotional/mental health impairments. Additionally, the nature of the secondary selected categories suggests a deficit-oriented interpretation of impairment; while it is true that a single diagnosis can impact an individual in multiple ways, that does not necessarily mean the person has multiple types of impairments. For example, the authors, who all experience anxiety, have experienced cognitive impacts from this emotional/mental health disorder. However, anxiety requires emotional/mental health supports to reduce its impact, which reduces its' cognitive impacts; cognitive supports alone are not useful.

B. Prevalent views about career viability

Table III presents the percent of careers practicing physicists believe are viable for individuals with specific diagnoses with shading on a scale of highest (green) to

TABLE III: Percentage of participants who responded that each career was viable for individuals with the categories of impairment. Green shading is on a scale from low (white) to high (green) percent who responded viable.

Career	Hr	V	C	E/M	P/M	Hl
Teacher	75	86	79	83	88	78
Professor	79	88	80	87	91	78
Engineer	94	86	85	93	89	81
Data analyst	99	88	85	95	96	82
Researcher - Theory	97	92	83	95	96	80
Researcher - Experiment	91	75	83	93	73	78
Researcher - Computation	99	91	85	95	97	81
Science communicator	79	91	82	86	93	81
Government sector	93	93	87	93	94	82
Private industry sector	93	92	87	93	92	82
None of these careers	0	3	6	2	3	7

Hr: hearing; P/M: physical/mobility; Hl: health; C: cognitive; E/MH: emotional/mental health; V: visual; U: unsure.

lowest (white). First, we notice specific combinations of category of impairment and career were more frequently deemed not viable. For example, the least viable combinations were teaching careers and hearing impairments (75%), experimental researcher and visual impairments (75%), and experimental researcher and physical/mobility impairments (73%). Comparing across categories of impairment (i.e., columns in Table III), we see that cognitive and health impairments tended to have careers deemed less viable than other categories of impairment. Comparing across careers (i.e., the rows in Table III), we see teacher and professor have lower trends of viability compared to other careers for similar diagnoses. When comparing across diagnoses, the difference of the believed viability between teacher/professor and other designated careers is minimal for those with physical/mobility (88% viable for teacher, 91% for professor) and visual impairments (86%, 88%) compared to other careers, but the gap becomes larger when examining responses for hearing (75%, 79%), health (78%, 78%), cognitive (79%, 80%), and emotional/ mental health (83%, 87%) impairments when compared to the viability of other careers.

C. Perceptions of career viability by disability experience

We used participants' responses about their personal disability experience (i.e., identify with a disability; do not identify with a disability but have a personal contact who does; no personal contact with a person who identifies with a disability) to disaggregate responses about career viability. Results are presented in Table IV, with the three numbers in each cell corresponding to participants who stated they had a personal experience/close contact with a disability/no contact who identified with a disability.

The shading corresponds to the difference in percentage of participants in each disability experience bin who deemed the career/impairment combination viable, with pink indicating a 10-15% difference, light red indicating a 15-20% difference, and dark red indicating greater than a 20% difference. For example, while 100% of participants who identified with a disability responded that a career in private industry was viable for a person with anxiety, only 79% of participants with no personal contact who identifies with a disability deemed this combination viable and this cell is colored dark red due to the 21% difference in responses by personal disability experience. We focus our analysis here on general trends and will conduct statistical analysis in future work [13].

When analyzing by career (i.e., the rows in Table IV), there were a greater number of large differences in viability by participants' disability experience for experimental researcher (blindness: 25%, learning disability: 21%, traumatic brain injury: 24%, multiple sclerosis: 25%) and computational researcher (blindness: 21%, learning disability: 23%). Additionally, teacher and professor careers had the largest number of career/diagnosis combinations with more than a 10% difference in viability across participants' disability experience. When evaluating across diagnoses (i.e., the columns in Table IV), there is a 17% average decrease in the belief of the viability of careers for someone with a learning disability across all careers, and a 14% average decrease in the belief of the viability of careers for someone with dyslexia.

One interpretation for these findings is that, without knowledge of the experiences of individuals with specific impairments, we rely on societal tropes about such impairments [15]. For example, participants may have been considering the social interactions required for a career as a teacher or professor when they responded that these careers were less viable for individuals with anxiety, depression, or PTSD. However, all three authors of this paper identify as teachers and/or professors who have been diagnosed with anxiety and depression. Similarly, participants who responded that researcher, engineer, and data analyst careers were more viable for autistic individuals may have been relying on depictions of autistic individuals as more interested in science, numbers, and tinkering than neurotypical individuals [14].

V. IMPLICATIONS

Combining the findings of Table II and Table III, practicing physicists are making implicit decisions about the viability of careers, and contributing to ableist environments without knowledge of disability diagnoses. However, placing Dis. people in an environment with people who have ableist tendencies for the purposes of increasing their experience with Dis. people, is both unhealthy and unjust for

TABLE IV: Percentage of participants who responded that listed careers were viable for individuals with listed diagnoses, segregated by disability experience in the format of Personal/Secondary/None. Shading corresponds to the level of difference between experiences. Pink: 10-15% difference; Light Red: 15-20% difference; Dark Red: >20% difference.

Career	Deafness	Blindness	Cblindness	Autism	ADHD	Dyslexia	LD	TBI	Anxiety	MS	Lupus
Teacher	79/75/63	76/75/63	100/98/95	79/74/68	88/89/74	93/86/74	78/78/63	72/66/63	95/86/79	91/89/84	90/89/79
Professor	83/79/63	74/80/68	100/98/89	84/82/79	90/87/79	93/88/74	78/72/63	71/66/63	93/86/84	95/91/84	90/88/84
Engineer	97/93/84	71/76/63	100/96/89	86/93/89	91/91/84	93/90/79	79/81/68	72/73/63	98/93/89	93/92/79	90/89/89
Data analyst	100/98/100	78/79/63	100/98/100	88/94/84	91/91/84	95/89/79	81/83/63	72/73/68	98/97/89	95/95/84	90/90/89
Researcher - Theory	97/98/95	79/88/84	100/98/100	86/94/89	90/90/84	93/91/84	78/71/58	71/70/53	98/97/95	95/94/79	90/91/95
Researcher - Experiment	90/91/84	53/58/32	95/94/89	86/91/84	90/90/84	95/91/79	79/76/58	71/69/47	98/96/89	88/80/63	90/88/84
Researcher - Computation	98/98/100	84/83/63	100/98/100	88/95/95	91/90/89	97/93/84	81/78/58	72/73/58	98/97/95	95/95/89	90/89/89
Science communicator	81/80/63	86/84/79	100/96/95	79/78/58	93/90/79	93/86/74	79/81/74	71/74/79	95/86/79	93/92/79	90/88/84
Government sector	98/93/74	88/89/89	100/97/89	91/89/84	93/91/89	95/91/89	90/86/74	74/76/79	98/93/84	95/93/79	90/89/79
Private industry sector	95/93/84	86/86/84	100/96/89	90/92/89	93/91/89	95/93/89	90/83/74	74/75/79	100/93/79	95/93/79	90/89/84

the Dis. individuals involved.

While we have used quantitative data to represent the beliefs of practicing physicists in this paper, it is important to note that we do not believe the solution is a quantitative one, such that ableism will be fixed at 90-100% viability and knowledge. Rather, we believe that in the ideal community, anyone who wants to participate in the physics community can meaningfully participate without experiencing barriers due to being Dis.

A. Implications for Physics Mentors

For mentors of physics students, whether Dis. and not, it is necessary to continually interrogate assumptions and beliefs about Dis. people and the structures that they exist in. The physics education research community (the authors included) may tend to believe that we are good people, and therefore, do not have any discriminatory/ableist beliefs [17]. However, these two statements are not mutually exclusive. One can be a good person, but still hold ableist beliefs due to the systemic natures of the structures that we support. While the majority of participants in this study had some personal experience(s) with disability, some still held ableist beliefs about who was able to do physics and have specific physics careers. Ableism is not limited to able-bodied individuals [18], nor is it a feature of "bad" people. To make our community a more inclusive environment for all, active steps towards education and an interrogation of the existing structures are required.

B. Implications for Researchers

Many mentors of physics students are also researchers and may oversee a variety of students and other researchers within a laboratory. Therefore, all the implications for mentors also apply to researchers. Yet, an additional implication exists for practicing physicists in the field. Primarily, if one sincerely believes that there are certain careers that those with impairments cannot do, it is imperative to interrogate whether all ways on engaging in this research/career are not viable for those with specific diagnoses. We invite researchers to think expansively about what it means to participate in their field. It is often possible that tasks previously thought of as not possible are able to be done using technology. For example, astronomical data typically analyzed through sight can be sonified and analyzed through hearing [19,20]. Portions of the research can be done by people with specific impairments while other portions that are carried out by others without the Dis. person missing out on salient component of the research. For example, when a planetary science research team is awarded data collection time on a sub-orbital flight, not all members of the research team are invited to collect data on the flight. Additionally, the physical structures surrounding the research could be modified to be more inclusive to Dis. people. For instance, modifications could be made to the physical laboratory layouts or tools could be acquired to allow people with physical/mobility impairments to reach portions of the experimental setup.

V. NEXT STEPS

In future analysis, we plan to explore whether participants' understanding of specific diagnoses and/or personal physics career impacts their responses about the viability of physics careers for Dis. People. Additionally, we plan to interview interested survey participants to explore their beliefs more richly about career viability for Dis. people.

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