Practicing Physicist's Perception of the Viability of Physics Teacher and Professor Careers for Individuals with Disabilities

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The perceptions that physics mentors have about disability in physics influences how they interact with their mentees, and negative biases against disability can influence students to feel discouraged within the physics community. We administered the Disability and Physics Career Survey (DPCS) through physics-specific listservs and at physics-specific conferences to measure practicing physicists' knowledge about disability and their beliefs about the viability of physics careers for individuals with a variety of disability diagnoses. This study uses Cochran's Q and McNemar's R to compare how practicing physicists' perceptions of the viability for the careers of teacher and professor depend on the impairment that an individual is diagnosed with. We find that practicing physicists view these careers as non-viable for those with cognitive impairments and hold other unconscious biases that we outline and interrogate.

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I. INTRODUCTION

The culture of the United States (U.S.) is permeated by ableism, which is the tendency for social groups and societies to value and promote able bodies against those who are 'less able' [1]. Physicists are influenced by the views of other physicists as well as the culture of U.S. society [2]. Thus, views of disability also impact the employment of individuals that identify with a disability in physics and STEM. In 2019, of all graduates awarded doctorate degrees in STEM, 9% reported identifying with at least one disability, and 9% of individuals currently employed in STEM identified with a disability [3]. Though it is possible that this is due to a lack of self-reporting, this marks a sharp decline from undergraduate enrollment where students with a disability are 20% of the student body [4]. Research has shown that STEM professionals hold more negative views about disability than peers in other disciplines [5]. This could be one of the factors to the lower number of individuals with disabilities in STEM graduate school and careers.

Using the Disability and Physics Career Survey (DPCS) [6, 7], we gathered data about the knowledge that practicing physicists (i.e., individuals who teach courses, write, or conduct research about physics in academic, government, or private sectors) hold about disability, and their views about the viability of physics careers for those identifying with different impairments. This study will focus on the second aspect of the DPCS regarding practicing physicists' views on the viability of careers. It is our goal that outlining and discussing the current perceptions of disability in physics careers can allow the reader to interrogate their own perceptions, highlight products of ableism that exist within our community, and identify areas for mentor training at the personal and community levels. Our research question is: How do practicing physicists' perceptions of the viability of teacher and professor in physics depend on specific impairments?

We suggest this because perceptions about career viability may impact how physicists interact with students or research mentees. Previous research has shown that unconscious perceptions of their research mentors and professors do influence how comfortable students feel interacting with them [6-8]. Additionally, students may feel discouraged to disclose their impairments or get accommodations [6, 7].

II. POSITIONALITY AND LANGUAGE

Our social identities can impact how the research is conducted and are important to outline, especially when researching marginalized communities. [9] The members of the research group identify with a range of impairments which include emotional/mental health, physical, hearing, and health impairments. Usage between person-first (e.g., person with a disability) and identity-first (e.g., disabled person) depends on the context and preferences of individuals with disabilities [10, 11]. For the purposes of this paper, we selected person-first language because we thought it would be most understandable to practicing physicists with varied levels of experience with disability.

III. METHODOLOGY

A. DPCS development

The DPCS is a multi-part survey designed to examine the knowledge about disability that practicing physicists hold and their beliefs about the viability of careers for individuals with a variety of impairments. The first section of the DPCS explores whether physicists can categorize diagnoses into relevant impairment categories, where relevance was defined by the researchers' interpretation of literature definitions of each impairment. These definitions were not given to those taking the survey but were left up to interpretation for the survey-taker. The reasonings for the categorizations by the research team have been published in previous work done by the research group [6, 7].

Table I. Categorizations of each impairment from the DPCS

Impairment	Category
Hearing	Deafness (Deaf)
Visual	Blindness (Blind)
	Colorblindness (Colorblind)
Cognitive	Autism
	ADHD
	Traumatic Brain Injury (TBI)*
	Dyslexia
	Learning Disability (LD)
Emotional/Mental Health	PTSD
	Anxiety
	Depression
Health	Lupus
	Traumatic Brain Injury (TBI)*
Physical/Mobility	Paralysis (Para)
	Multiple Sclerosis (MS)

**TBI is coded as both Cognitive and Health according to previous literature. [6]*

Table II. Participant Demographics (N=237)

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%
Career	University Faculty: 66%, Government: 11%, Industry: 17%, Student: <1%, High School Teacher: <1%, Other: 11%

The second section of the DPCS explores participants' beliefs about the viability of physics careers for those with differing impairment diagnoses. Participants were given a series of diagnoses, and then asked to choose which careers were viable for a person with that diagnosis. The diagnoses that were given as examples are listed in Table I with their respective categorizations as done by the research team. The development of the DPCS was reported in a previous study [7]. Changes were made to the version of the DPCS reported in this paper. First, the number of diagnoses given to participants was shortened from 28 to 14 to lessen confusion in language for international practicing physicists, shorten the survey, and focus more on certain categories of impairment, such as "cognitive" which previous research has found that physicists struggle with understanding [7]. The common diagnoses and careers choices included in the DPCS were a result of open-ended participant responses to a former version of the survey as well as supporting literature.

The physics careers, common for those graduating with physics degrees, included were teacher, professor, engineer, data analyst, theoretical researcher, experimental researcher, computational researcher, science communicator, government, and private industry.

B. Participant recruitment and demographics

Participants were recruited at APS conferences, a non-APS but STEM-specific meeting, and the APS and Two-Year College Listserv [6]. Participants were given a $5 gift card for completing the survey. Table II displays demographics for the participants. Table IV displays the total number of 'viable' responses for each impairment.

C. Cochran's Q and McNemar's R

To address our research question, we need to analyze how a participant's response about the viability of a physics career changes across impairment. Since our data is dichotomous (i.e., viable/ not viable) with responses across categorical levels (i.e., impairments), one's first instinct may be to apply Chi-squared. However, because each participant is responding to a series of prompts about the viability of careers for a range of impairments, this sample violates an assumption for Chi-Square that each subject contributes data to only one cell [12]. Thus, we sought a statistical test that is appropriate for this design. Using chi-squared also would not tell us how individuals' responses changed, which is needed to address our research question.

Cochran's Q is a test used to determine if there are differences on a dichotomous variable (i.e., viable/not viable) between three or more related groups (i.e., the various diagnoses) [13, 14], which matches our sample and research question. McNemar's R uses a different contingency table than chi-squared, as shown in Table III, where each participants' response is tallied by how they responded about the viability of a career across impairments: the career was considered viable (or not viable) for both impairments or the career was considered to be viable for one impairment but not for the other. This allows us to explore how a change in impairment impacts each participant's response about career viability.

Using Cochran's Q and McNemar's R statistical methods, we analyzed whether there are significant differences in participants' views about the viability of careers for different diagnoses. First, we performed Cochran's Q to reveal whether changing the diagnosis for a given career created a significant difference in the perceived viability of that career. If Cochran's Q showed significance, then we performed McNemar's R pairwise tests to measure which pairing of diagnoses showed a significant difference in viability. McNemar's R test is similar to Cochran's Q but specialized to two related groups [13, 14]. A Bonferroni correction after the McNemar's R test was used to account for any overestimation in the calculation due to the number of pairwise tests performed for each career.

In this paper, we focus on two careers from the DPCS and Cochran's Q analysis: teacher and professor. These careers were chosen due to their relevance for the target audience for this paper, and for readers to compare their own inherent assumptions about which careers are viable for certain diagnoses.

IV. RESULTS

Cochran's Q was significant for both careers ($p<0.001$). The McNemar's R analysis is displayed in Table V. Each row and column represent a diagnosis within a career. The cell either lists numbers, representing the odds ratio for pairwise McNemar's results and corresponding categorization of p-values, or 'NS,' representing a non-significant pairwise result.

Table III. McNemar's R and Odds Ratio Example Table for the Viability of Teacher Regarding Deafness and Lupus

		Deafness Viable	Not Viable
Lupus	Viable	171	49
	Not Viable	15	15

Table IV. Total Raw Responses for Viability for Teacher and Professor. N= 250, so the number responding non-viable for the career-impairment combination is 250 minus the number in that cell.

Total Viable	**Deaf**	**Lupus**	**Para**	**PTSD**	**Blind**	**Dyslexia**	**Autism**	**Anxiety**	**ColorBlind**	**ADHD**	**MS**	**Depression**	**LD**	**TBI**
Teacher	186	220	217	206	182	218	185	220	247	218	224	224	190	169
Prof	196	220	227	217	193	220	203	220	246	218	228	225	181	168

TABLE V. McNemar's R for teacher between various diagnoses. The number in each cell is the Odds Ratio, with the sign indicating the directionality. A positive/negative number indicates that the row/column impairment was more likely to be viewed as non-viable. ★ indicates a p-value between 0.01 and 0.05. ★★ indicates a p-value between 0.001 and 0.01. ★★★ indicates a p-value less than 0.001. N.S. indicates that the pairwise comparison was not significant. A – is used to show the mirrored aspect of the table. The number in the first row of each cell indicates the odds ratio and significance for teacher. The second row indicates the odds ratio and significance for professor.

	Deaf	**Lupus**	**Para**	**PTSD**	**Blind**	**Dyslexia**	**Autism**	**Anxiety**	**Colorblind**	**ADHD**	**MS**	**Depression**	**LD**
Lupus	-3★★★ -2★	-	-	-	-	-	-	-	-	-	-	-	-
Paralysis	-3★★★ -5★★	NS NS	-	-	-	-	-	-	-	-	-	-	-
PTSD	NS NS	NS NS	NS NS	-	-	-	-	-	-	-	-	-	-
Blind	NS NS	-4★★★ -3★★	5★★★ 6★★★	NS 3★	-	-	-	-	-	-	-	-	-
Dyslexia	-6★★★ -3★	NS NS	NS NS	NS NS	-6★★★ -3★★	-	-	-	-	-	-	-	-
Autism	NS NS	3★★★ NS	3★★★ 3★★	NS NS	NS NS	4★★★ NS	-	-	-	-	-	-	-
Anxiety	-4★★★ -3★	NS NS	NS NS	NS NS	-5★★★ -3★★	NS NS	-5★★★ NS	-	-	-	-	-	-
Colorblind	-123★★★ -101★★★	-28★ -27★	-16★★ NS	-83★★★ -59★★	-131★★★ -28★★★	-59★★ -53★	-55★★★ -44★★★	-55★ NS	-	-	-	-	-
ADHD	NS NS	1★★ NS	1★ NS	NS NS	NS -2★	1★★ NS	NS NS	1★★ NS	16★★★ 57★★	-	-	-	-
MS	-5★★★ -4★★★	NS NS	NS NS	NS NS	-6★★★ -5★★★	NS NS	-5★★★ -4★	NS NS	NS NS	-2★★★ NS	-	-	-
Depression	-9★★★ -5★★	NS NS	NS NS	NS NS	-5★★★ -3★★★	NS NS	-8★★★ NS	NS NS	NS NS	2★★★` NS	NS NS	-	-
LD	-1★★★ NS	NS 4★★★	NS 6★★★	NS 4★★★	-1★★★ NS	NS 8★★★	-1★★★ NS	1★★★ 6★★★	115★★★ 131★★★	5★★ 13★★★	NS 6★★★	NS 23★★★	-
TBI	NS 2★★	7★★★ 6★★★	5★★★ 7★★★	4★★★ 5★★★	NS 2★	6★★★ 8★★★	NS 3★★★	6★★★ 7★★★	157★★★ 157★★★	NS 14★★★	15★★★ 13★★★	7★★★ 8★★★	2★★★ NS

The table combines the results of the McNemar's R test for teacher and professor by splitting each result as teacher/professor respectively for each cell where teacher is the first row and professor is the second. The odds ratio is the odds that one impairment was viewed as non-viable compared to another. In these tables, a positive odds ratio indicates that participants were more likely to claim that the row impairment was non-viable, while a negative odds ratio indicates that participants were more likely to claim that the column impairment was non-viable. For example, the +4 of dyslexia/autism (column/row) indicates that participants were 4 times more likely to classify autism as non-viable for a teaching career compared to dyslexia and the -3 of deafness/lupus indicates that participants were 3 times more likely to classify deafness as non-viable for a teaching career compared to lupus. All values are greater than or equal to 1. Due to rounding, some cells show a result of 1.

The odds ratio is found by taking the quotient of cells denoting opposite results in viability. For example, as shown in Table III, for deafness and lupus, it is the quotient of the cell with all who said deafness was viable and lupus was not viable (i.e., 15) and the cell with all who said deafness was not viable and lupus was viable (i.e. 49). The quotient of these two values is either 49/15 or 15/49. After this quotient is found, the result that gives a value greater than or equal to 1 is the odds ratio. For Table III, the odds ratio between deafness and lupus regarding teacher is 49/15 or approximately 3.27, which is rounded to 3. Finally, when represented in table V, because Deafness was perceived as more non-viable, and is the 'column' impairment, it is represented as a "-3".

V. DISCUSSION

A. Common findings about perceived career viability teacher and professor careers

Using Cochran's Q, overall, we found that participants' views about the viability of physics teacher and professor careers depended on diagnosis. So, we used McNemar's R to identify specific pairs of diagnoses between which participants' responses varied.

. Additionally, all significant results in colorblindness had other diagnoses being perceived as more non-viable compared to colorblindness. This suggests practicing physicists view teacher and professor as non-viable careers for those with deafness, blindness, learning disability and traumatic brain injury. We hypothesize that the bias against those with learning disabilities may stem from stereotypes of those with learning disabilities being 'slow,' or not able to truly function in higher education [15]. We also believe that the bias against those with traumatic brain injuries is due to a lack of understanding of what a traumatic brain injury truly is. Previous research done by this group [6] shows that practicing physicists do not have a good understanding of traumatic brain injuries.

For both teacher and professor, compared to other impairments, participants were more likely to say that these careers were non-viable for someone who identifies with deafness or blindness. This implies that practicing physicists perceive hearing and sight as an integral part of being a teacher and/or a professor.

For teacher and professor, our findings suggest physicists do not perceive physical/mobility impairments (e.g., multiple sclerosis and Paralysis) or health impairments (e.g., lupus) to be indicative of teacher and/or professor being non-viable careers for an individual identifying with that impairment. It is possible physicists' views on such impairments have been impacted by prominent disabled physicist, Stephen Hawking [16].

B. Findings about autism for professor

Certain outliers appeared when categorizing the viability of teacher and professor for different diagnoses. Participants were more likely to say that autism spectrum disorder was non-viable compared to other diagnoses within the context of a teaching career, but to a much lesser degree regarding the viability of being a professor with autism. We attribute this to stereotypes about autistic people, such as being extremely knowledgeable about niche topics and struggling with social skills as matching with stereotypes such as the absent-minded professor. This may lead to a perception that autistic students may succeed better as a professor than as a teacher. This perception is still harmful, as it is based in harmful stereotypes. Additionally, when students with autism don't fit the mold of the above stereotypes, they still end up discouraged and diminished by the community at large.[17]

V. LIMITATIONS

We did not investigate physicist's interpretations of each career and diagnosis. For example, it is possible that each participant has a different interpretation of what a teacher is. Additionally, people's experiences with diagnoses and impairments can vary between individuals. Each disabled individual has a unique experience with their disability/impairment.

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VI. IMPLICATIONS

Participants perceive learning disabilities, traumatic brain injury, blindness, and deafness as barriers to careers of teacher and professor. They also perceive teacher as a non-viable career for those with autism compared to other impairments but perceive autism as less of a barrier for professor, which we postulate may be due to stereotypes surrounding autism.

Based on our analysis, we find that that physicists are likely making judgement calls on the viability of teacher and professor for people with disabilities, viewing some careers as more non-viable for certain diagnoses compared to others. This perception of viability may have impacts for current students with disabilities in their class, where unconscious perceptions may influence how they interact with these students and their research mentees [18, 19]. This may lead to disabled students feeling discouraged in the physics community due to the interactions that they have with their professors and research mentors.

Additionally, this may lead to physicists and mentors discouraging disabled students from continuing to participate in the physics community due to their belief in the viability of these careers for their students. If a professor or mentor believes that a student with a learning disability cannot succeed as a future professor, they may discourage that student from continuing in their post-secondary education [17-20]. Even if the professor or mentor does not overtly discourage the student, students may choose not to disclose impairments, or feel comfortable discussing their disability due to fears about how their mentor may perceive their disability [17-20].

It is important to highlight individuals with impairments in a variety of physics careers. Societal perception of physicists does not regularly feature disabilities as a part of those doing physics due to the societal impact of ableism. When individuals with a disability are referenced within society, the main examples used are autistic individuals or Stephen Hawking [16, 17]. These examples can lead to many of the previous perceptions within our results, such as professor being 'more viable' for autistic individuals or physical/mobility, and health impairments not influencing the viability of teacher and/or professor. By highlighting a greater number of individuals that identify with disabilities in a variety of physics careers, the representation of a physicist and a physicist with a disability can also change as well.

We should also strive to understand what it means for someone to have different impairments. This step towards understanding may allow us to interrogate our preconceived notions about what is necessary to succeed as teacher and/or a professor.

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