Planning for participants' varying needs and abilities in qualitative research

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[This paper is part of the Focused Collection on Qualitative Methods in PER: A Critical Examination.] All people vary in their needs and abilities; however, typical research practices do not consider these variations, which likely impacts who participates in research studies. Additionally, few PER studies have investigated aspects of disability or reported disability identity. Combined, this means that PER researchers typically do not seek out the experiences of disabled people and disabled people might not have access to participate in research studies. In this paper, we demonstrate how a research team can use principles from Universal Design for Learning and the Variation Planning Tool to anticipate expectations of ability and create flexible options in a qualitative research study. We then demonstrate how different interview structures can impact disabled participants through a case study with three participants, all of whom self-identified as students with attention deficit-hyperactivity disorder. Finally, we conclude with implications and suggestions for researchers in planning their study designs. It is critical that, as physics education researchers, we anticipate, welcome, and support disabled participants in our research, particularly as interviews are a prevalent method in the field. Through the example presented in this paper, we hope to encourage researchers to examine their own methods through the lens of accessibility and to offer alternative formats in their research design as a means to combat ableism and to provide access to all research participants.

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I. MOTIVATION

In physics education research and physics education, disability identity has been understudied and largely unexamined, particularly when evaluating higher education efforts [1–3]. Over the last four decades, there has been a large push toward active learning in science, technology, engineering, and mathematics (STEM) [4], which has taken a variety of forms over the years, almost all of which involve some amount of group work. In physics alone, we have Tutorials in Introductory Physics [5], Physics by Inquiry [6,7], Maryland Tutorials [8,9], Modeling Instruction [10,11], SCALE UP [12], clicker questions [13,14], and many others [15–18]. There have been many evaluation studies focused on conceptual understanding [4,19–24], self-efficacy [25,26], attitudes and beliefs [27,28], identity [29], and skills [30,31]. However, very few of these studies consider disability identity as part of the data collection or curriculum evaluation.

Nevertheless, disabled students represent a significant portion of the student population in higher education, making up at least 20% of undergraduate students, and this proportion has continued to grow over the last decade [32,33]. Within STEM subjects, we see a similar proportion of disabled students as in other disciplines. The National Science Foundation (NSF) reports that disabled and non-disabled students enroll in STEM majors in proportions at similar rates [34]. Furthermore, studies suggest that the portion of disabled students in higher education is larger than those registered with the local Office of Disability Services since many (approximately two-thirds of all disabled students) students do not register for accommodations with their institution [32,35].

Despite making up roughly a fifth of the student population, researchers have often not planned for disabled students in physics education research studies, let alone

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explicitly sought out disabled students' experiences in our classrooms (with a few notable exceptions [36–38]). There are likely many reasons for this lack of representation in research, including (i) a lack of awareness and training for faculty on disabilities and accommodations [39–43], (ii) stigmas around disabilities in science and society as well as the ableism endemic in society [44–47], and (iii) a lack of literature on how to support disabled post-secondary STEM students [2,48]. Moreover, researchers typically do not consider or assess the chosen research methods for accessibility. If we have not checked that an online survey is compatible with screen readers, then the survey is not intentionally accessible to visually impaired students, for example. Similarly, if we design interviews to be conducted in-person, the study may not be accessible for students with mobility impairments. It is critical that, as physics education researchers, we anticipate, welcome, and support disabled participants in our research, particularly as interviews are a prevalent method in the field. Thus, to even begin to address the dearth of research and to address ableism and disablism in the academy [49], we must first examine our research methods to provide access for all participants.

In this paper, we focus particularly on qualitative interview methods and how to plan for the variations in ability among research participants. Our purpose in writing this paper is twofold: (i) demonstrate how a research team might plan for and include flexible options within a study design, and (ii) demonstrate how different interview structures can impact disabled participants in an interview study. Through the example presented in this paper, we hope to encourage researchers to examine their own methods through the lens of accessibility and to offer alternative formats in their research design as a means to combat ableism and to provide access to all research participants.

II. BACKGROUND

A. Social model of disability

There are many ways that people and societies view disability, and these models of disability vary in terms of where disability is situated. One common model of disability is the "individual" or "medical" model [50]. Under this model, disability is situated within the individual with an impairment, and the individual is expected to carry the onus of accessing society, such as undergoing medical procedures, or to experience exclusion from society. Conversely, the social model situates disability at the interaction of an individual with impairments and an environment, where the environment includes physical, social, economic, and political components [51,52]. An individual is disabled if the *environment* does not support their access.

For example, a Deaf person could be disabled during a virtual meeting if neither ASL interpretation nor closed captions were provided. Under the medical model, an individual may be expected to make individual adjustments to access an inaccessible environment. In this example of a virtual meeting, a Deaf attendee may be expected to use hearing aids, cochlear implants, and/or lip reading. However, under the social model of disability, the same person could be provided access if the meeting employed closed captioning. In this case, the individual did not change; rather, the environment changed. In a classroom setting, an instructor could respond to a student's lack of access through the social model by enacting inclusive design and providing accommodations [53]; on the other hand, an instructor operating through the medical model may expect students to use medications to succeed in the current classroom environment [37]. With the social model, the onus for change is placed on society to identify and eliminate disabling barriers. We have summarized the differences between the medical model and the social model in Fig. 1, which is modified from a similar summary by Goodley [54].

We explicitly employ the social model in this work, focusing on how interview methods and structures (the environment) either support or hinder access. Interested readers can learn more about the medical model, social model, and alternative models by reading [55], and consulting references within, such as [56,57] to learn more about the medical model, and [52,58] to learn more about the social model.

There is no consensus about the language used to discuss disability. Some people prefer person-first language (e.g., "students with disabilities" or "person with a hearing impairment") because it emphasizes the person over the

	Individual or Medical model	Social model
Model focuses on:	Impairment	Society
Relationship between disability and impairment:	Disability = impairment	Disablism over impairment
Disability arises from:	Individual deficiency	Societal deficiencies
Access occurs through:	Individual adjustment	Social change and revolution

FIG. 1. Highlights of the differences between the medical model of disability and the social model of disability, based on what the model focuses on, the relationship between disability and impairment, where disability arises from and how access occurs. Modified from Goodley [54].

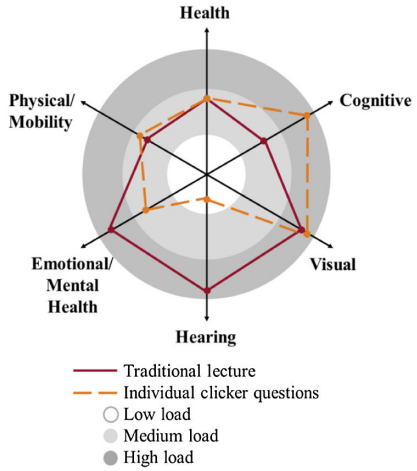
ability. Others, however, see impairment-first language as more consistent with the social model of disability (e.g., "disabled student") and as valuing the difference as an integrated part of the person's identity (e.g., "Deaf person") [59–62]. In this work, we will typically use impairment-first language to be consistent with the social model of disability; this language is also preferred by disabled individuals in our research team. When speaking about specific individuals, we will use their preferred language.

B. Universal Design as guiding framework

We frame our study using concepts from Universal Design, which was developed in the 1980s from universal design for architecture and is defined as "the design of products and built environments that are usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" [63,64] (p. 1). Extending from the Universal Design framework, Universal Design for Learning (UDL) applies the concepts of Universal Design to the learning context [65]. UDL is a framework for the development of curricular materials that are designed to be inherently accessible to and supportive of the broadest range of learners possible. Typically, curricula are thought of as "one size fits all students" however, UDL does not take up this framing because current neurological research indicates that there is no "average" student [66]. The UDL framework focuses on *proactively* designing curricula to support the inherent variations among learners instead of addressing their varying needs, abilities, and interests on a case-by-case basis as they arise. The UDL framework is composed of three principles: (i) provide multiple means of representation (present the information in multiple formats such as text, diagrams, equations, sounds); (ii) provide multiple means of action and expression (provide students options in the means of expressing their understanding and physically interacting in the learning environment); and (iii) provide multiple means of engagement (allow for options and variations in terms of motivations and interests among students). In this study, we apply the concepts of Universal Design by investigating proactive supports to provide access for disabled research participants.

C. Variation Planning Tool

Throughout this paper, we will use the Variation Planning Tool [67] (VPT) to explore interview actions that could support disabled participants to meaningfully engage in the interviews. Rooted in UDL, the VPT is designed as a tool for instructors to evaluate the anticipated demand of course activities and features. The VPT is composed of six dimensions of ability: (1) physical/mobility (strength, dexterity, and endurance); (2) health (regulation of bodily systems); (3) cognitive (plan, remember, understand, and interpret); (4) visual (acuity and color); (5) hearing (loudness and pitch); and (6) emotional/mental health (feelings, emotions, attitudes, and beliefs) [68]. To use the tool, instructors evaluate the expected load (i.e., low, medium, high) of each type of activity in their course for each dimension of ability. Designations of high, medium, and low are not meant as a precise delineation in the VPT, but rather as the instructor's best estimate of their expectations for students. After using the VPT, instructors should have a clear idea of what abilities are expected to be used in the course activities. If all the course activities are loading high on a particular dimension, this indicates to the instructor to consider offering alternatives or adjusting the course activity. For instance, if all the course activities have a high expectation along the visual



		Phys/Mob	Hearing	Visual	Emo/MH	Cog	Health
Classroom structures	Traditional lecture	Medium	High	High	High	Medium	Medium
	Individual clicker questions	Medium	Low	High	Medium	High	Medium

FIG. 2. Two representations of an analysis using the Variation Planning Tool for two typical classroom practices: traditional lecture and individual clicker questions. On the left, the figure marks the six dimensions of analysis spread in a circle with shaded gray circles to denote a low load (white shading), a medium load (medium gray shading), and a high load (dark gray shading). The red, solid line shows the loading for traditional lecture while the orange, dashed line shows the loading for individual clicker questions. On the right, the VPT analysis is summarized in a table format, showing the high, medium, and low loadings for each dimension of ability.

dimension, the instructor may consider adding a verbal explanation to the activity instructions or creating an audio supplement to the activity.

As an example, Fig. 2 shows a complete VPT analysis for a course that utilizes traditional lecture and individual clicker questions. Both traditional lecture and individual clicker questions load high on the visual dimension of ability because students are expected to watch the front board and/or PowerPoint slides during traditional lecture and are expected to look at the slide for individual clicker questions. This means that if a class is only composed of traditional lecture and individual clicker questions, students who have strengths on the visual dimension are enabled to participate and students with visual limitations are disabled in their participation. The instructor could mitigate the impacts of this visual focus by reading the question out loud and verbally describing relevant information or by providing alternative means of accessing the visual information (e.g., tactile representations, digital access via screen-reading software). It is important to note that the VPT is *not* designed to evaluate individuals, a particular impairment, or a specific diagnosis. Instead, the tool evaluates the expected level of load that an instructional practice places on students in the course. Instructional design, in addition to mitigating features, can allow or prevent access, either enabling or disabling students from participating fully in the course.

D. Clarifying language and use of VPT

Within our study, we used the VPT for two distinct purposes: (i) to anticipate the demand of the different interview formats and (ii) to describe the impacts of different interview structures for our participants. While we use the same dimensions of ability, we intentionally use different language for these two purposes.

When using the VPT to anticipate the demand of different interview formats, we use "high," "medium," and "low," to describe the expectations of each activity along a particular dimension. When using the VPT to describe the impacts on participants, we shift our language to use "disabling," "mitigating," and "enabling" to align with language from the social model of disability. When we describe an interview structure as disabling, we mean that the interview structure was taxing or burdensome along one or more of the dimensions of ability, preventing access or making access challenging in some way for the participant (e.g., disabling the student from access and participation with the interview). When we describe an interview structure as mitigating, we mean that the interview structure improved, supported, or eased an otherwise disabling aspect of the interview (e.g., lowering barriers to access and participation). When we describe an interview structure as enabling, we mean that the interview structure allowed or supported the participants' access to the interview.

As an analogy, one could think of the interviewee's access in terms of a dial with a negative region, a zero, and a positive region, where zero could be viewed as a neutral experience or the minimum level of access. One could think of a structure or experience as disabling if it would move the dial from zero into the negative region. One could think of structure as mitigating if it moved the dial from the negative region back towards zero. One could think of a structure as enabling if it moved the dial from zero into the positive region. There may also be scenarios where an enabling structure is removed, representing a shift from the positive region back towards zero. While we did not see this situation in our data, this could describe students' experiences when virtual options that were available during the COVID-19 pandemic were removed in the "return to normal." Using this analogy, we are not trying to define what a universal "zero" would mean or compare experiences across different participants. Similarly, we are not trying to describe if something is "more disabling" or "less disabling" for a participant. Rather, we are simply looking at the shifts themselves or how the interview structures impacted the participants.

E. Applying UDL principles and VPT to qualitative research contexts

In this paper, we extrapolate the VPT framing to planning qualitative research interviews. In creating a study design and picking methods, researchers make choices about the structures and implementation that have built-in expectations of participants along the same dimensions of ability. We posit that the VPT can also support researchers in designing methods for accessible data collection. In the subsequent sections, we outline how we changed and adapted a typical interview format (i.e., a one-on-one interview, where the researcher verbally asks questions from a protocol to a research participant who verbally answers the questions in the moment) to better allow for variation in participants' abilities. By modifying and examining existing interview formats, we hope to create a more accessible and inclusive study design.

While access is not often an explicit part of planning qualitative studies, we acknowledge that this work is situated in a rich history of qualitative methods and methodology, where interview methods are already diverse and often flexible in format. For example, an interview protocol may be designed as a structured interview or semistructured [69]. Interviews might be only verbal questions [70], or they might make use of other media—like watching a video clip with the participant in a stimulated-recall interview [71] or asking the participant to complete a card sort in the interview [72,73]. The types of questions in an interview frequently vary depending on the purpose and methodology selected for the study. For instance, there is a wide variation in how a case study is conducted [74], where the questions asked in an

interpretivist case study would vary greatly from those asked in a realist or comparative case study, despite both falling under the umbrella term of "case study" [75,76]. Therefore, there is a strong precedent in qualitative research to create flexible and adjustable study designs, depending on the purpose and goals of the study.

Furthermore, we are not the first to use the styles of interviews that we describe in the following sections. We outline our design process for the interviews in Sec. IV; however, we did not create the interview formats from scratch, and we were drawing from other examples in the field. For example, many researchers—in education research and beyond—have been conducting focus groups [77] and interviews via Zoom or other online platform for years [78], particularly with ongoing research projects during the COVID-19 pandemic. There are also examples in the literature of using Google Docs or other synchronized, web-based platforms for interview questions [79]. Similarly, there is precedent for inviting members outside of the research team into the interview process or for selecting interviewers that share similar identities with participants [80–82]. For instance, St. John *et al.* describe a study in which they invited individuals with an intellectual disability to be co-researchers in the study and to interview research participants with an intellectual disability [83]. Thus, we are not claiming to originate the interview formats in this paper; instead, our goal is to examine these formats using the UDL framework and the VPT, leveraging the existing interview formats to create a more accessible and inclusive study design.

In Sec. III, we outline the overall study design that we followed and the positionality of our research team. In Sec. IV, we detail how we planned for variability in our study design, describe the interview formats in detail, and show the VPT analysis for each interview format. Section V then describes how we implemented these interviews, our analysis process, and impacts of the different interview formats on our participants. We conclude with the discussion and limitations of our results (Sec. VI), areas for future work (Sec. VII), and the implications for researchers (Sec. VIII).

III. STUDY DESIGN

A. Positioning of the paper

This paper is a part of a larger project, which has two primary purposes: (1) to demonstrate how different interview structures can impact the experiences of disabled research participants and (2) to explore disabled students' experiences in different university settings (e.g., group work, lab classes, etc.). To that end, we conducted multiple interviews with the same students, where the format of the interviews varied to explore different interview structures and where the topic of the interviews varied to explore students' experiences in different settings.

We ultimately conducted four different types of interviews (further described in Sec. IV). The first was a typical oral interview, which focused on the students' experiences in a group-based, active-learning physics class. For this interview, we offered an in-person option and a Zoom option; however, all of our participants selected the Zoom option. The second was a document interview, where questions were placed in a shared, online Word document that students responded to directly in the document. This interview was fully asynchronous and focused on the students' experiences in lab-based classes. The third interview was a companion-guided interview, where the student selected someone that they felt comfortable with (e.g., a friend, roommate, or family member) as the "companion," who then asked the questions in the interview after meeting with the researcher and receiving a list of questions. The companion-guided interview focused on the students' experiences in general at the university. Finally, the fourth interview was a focus group interview that focused on students' experiences in the first three types of interviews. This paper only reports on the first purpose of the study and a subset of our larger dataset, namely, demonstrating how we designed the study and how different interview structures impacted our participants.

B. Positioning the research team

We highlight the identities and experiences of the authors in relation to this work. As the designers of the tools and study, the conductors of the interviews, and the analyzers of data, our respective backgrounds will influence our perspectives and interpretations. We would emphasize that many of our authors identify as disabled researchers, and their inclusion and perspective is crucial. Disability is not a monolith, but including people who experience ableism and disablism in their everyday life provides invaluable insight. We present and consider our backgrounds as a validity measure for this work.

1. Positionality of the design team

All members of the design team (D. M., E. S., and J. C.) identify as cisgender white women and physics instructors who have experience implementing inclusive practices and accommodations. The design team members have a range of disability identities, including health, physical/mobility, mental health, and cognitive diagnoses. Some members of the design team accessed accommodations during their personal education experiences, while others did not. These identities and experiences guide the design team to create inclusive experiences that minimize the need for individual-level self-advocacy such that access is provided to a broad range of individuals. We note a lack of gender, racial, ethnic, and career diversity among the research team, as well as the absence of individuals with visual and hearing impairments. This absence may have limited the interview styles we designed.

2. Positionality of the analysis team

The analysis of this research was led by a group of undergraduate researchers (R. L, A. R, H. C.) and were supported by an experienced qualitative researcher (V. S.) and a member of the design team (D. M.). This analysis team has a range of gender identities and disability identities, including physical/mobility, mental-health, and cognitive diagnoses. Some members of the undergraduate research team saw themselves reflected in the interviews with the participants in this study, and some drew on a personal history of supporting people with disabilities. All members of the analysis team drew on a background of teaching science classes with attention to inclusive practices and accommodations for students. In addition, H. C. and D. M. had previously conducted an extensive literature review on disability and accessibility in STEM education. The personal and professional experiences of this analysis team guided them in noticing nuances in the interview data and supported them in triangulating across experiences shared by the participants. We note that the analysis team had minimal racial or ethnic and career diversity as well as the absence of individuals with visual and hearing impairments. These absences may have limited our ability to notice and interpret the data along these dimensions.

3. Positionality of the interviewers

The interview lead (V. S.) ran all of the interviews in this study with support from one member of the undergraduate analysis team (H. C.). The lead interviewer is an experienced qualitative interviewer who typically follows semistructured conversational interview protocol designs. Her interview techniques center the participant and aim to build rapport and reduce anxiety about the interview format. As a result, she orients to interview protocols as guidelines to the conversation, frequently moving between questions, adding follow-ons, and pausing based on the social dynamics in the interview. She has experience running all of the forms of data collection used in this study with the exception of the companion-guided format. V. S. regularly trains researchers to collect qualitative data and to run qualitative interviews both in-person and over Zoom. In this project, she served as a mentor to H. C. who ran one oral interview with a participant. H. C. is new to qualitative interviewing, though she built on experience doing medical intakes in her volunteer roles. Neither V. S. nor H. C. have received any training on conducting interviews with disabled students.

IV. HOW DOES A RESEARCH TEAM BEGIN TO PLAN FOR VARIATION IN INTERVIEW STUDIES?

In this section, we describe the planning process that we used as a research team. Section IV A provides a brief overview of how we came up with the interview formats and why we selected the formats that we did. Section IV B then describes the procedures and actions that were taken by the interviewer and what would be asked of participants in each interview format. Finally, Sec. IV C describes the VPT analysis for the interview formats as well as describing any mitigating interview structures that we built into our process.

A. Coming up with formats

As a research team, we began the planning process by starting with a semistructured interview as the standard interview format in the field. We considered a typical interview, which consists of one researcher who conducts the interview with one participant. Interview questions are asked orally, where the participant is asked to respond in the moment. The researcher may ask follow-up questions not listed in the protocol, and the participant may ask clarifying questions to the researchers. Often, the researcher and the participant do not know one another prior to the interview. After starting with the standard interview, we identified two significant limitations of the format. First, there is a limitation on the time required. Participants are asked to answer questions in the moment and are asked to be in the same room without breaks (requiring a high load on the cognitive, health, and emotional/mental health dimensions of ability). Second, we are asking participants to share their thoughts and personal experiences with a stranger (high load on the emotional/mental health dimensions).

We then designed variations in the interview format to address different access needs: (1) oral interview; (2) document interview; (3) companion-guided interview; and (4) focus group interview. The oral interview represented the standard in the field. The document interview was designed to address the first limitation of the time required. By completing the questions asynchronously in a shared document, there is no restriction on the time spent and the participant may take breaks to manage any needs. The companion-guided interview was designed to address the limitation of talking with a stranger. Instead of being interviewed by an unfamiliar researcher, the participant would ask someone that they feel comfortable with to ask them questions and guide the conversation. The focus group interview was then added at the end to allow participants to compare or contrast their experiences with the other types of interviews. While we present evidence from the focus group interview, we do not analyze the focus group as a type of interview since participants were not asked to reflect on the focus group interview format itself.

B. Interview formats and procedures

In this section, we describe the design and implementation of the interviews.

1. Oral interview

The oral interview was designed as the first in the sequence with each participant and focused on the student's experiences in a group-based physics course. For the oral interview, each participant was offered the option of an in-person interview or completing the interview over Zoom. The interviews were scheduled to take 1 h, with approximately 45 min planned for interview questions and 15 min planned to cover introductory information. The interviews were recorded, and students had the option of recording both video and audio, or only recording the audio from the interview. Interview questions were provided at the time of interview solicitation (multiple days before the interviews), and upon entering the interview, the participant was guided through an online version of the consent form, and a brief, verbal outline of expectations was provided. (See Supplemental Material, document 1 [84] for the oral interview protocol.) While the interviewer did ask the questions shared ahead of time, there was opportunity for follow-up questions, and the direct sequence of questions might have changed depending on the conversation, following conversational interview techniques [85].

2. Document interview

At the end of the oral interview the interviewer described the process for the asynchronous document interview, focusing on the participant's experience in lab courses. The interviewer then asked the participant what time frame would work best for them to receive the document and also asked if a follow-up reminder would be helpful. The document for this asynchronous interview was prepared in Microsoft Word and shared via OneDrive online. (All participants had a school-paid-for account to access these documents that is FERPA and human subjects research approved.) The interviewer prepared the document with instructions at the top followed by prompts with space for responses (See Supplemental Material, document 2 [84] for the document interview protocol). The interviewer then sent an email with a link to the document, a written reminder of expectations, and set a soft deadline of one week. A reminder email was sent 1–2 days prior to that soft deadline and the interviewer inquired whether participants would need more time. Once the document was sent, there was no planned back and forth between the participant and interviewer; however, the interviewer said they were available for clarifying questions via email if needed.

3. Companion-guided interview

At the end of the oral interview, the interviewer described the goal of the companion-guided interview, focusing on the participant's general experiences at university. At this time, the interviewer invited the participant to consider someone they might ask to complete this interview with them. When the participant emailed the completed document interview, the interviewer requested the contact information of a personal contact for completing the next interview. Upon receiving that information, the interviewer emailed the personal contact and copied the participant. The email contained the overview of the questions to be covered in the companion-guided interview, and requested a brief conversation with the personal contact to go over the interview procedures or techniques. In that conversation (or via email), the interviewer went over the questions with the personal contact and described the process as a guided conversation and not a questionnaire to be completed. (See Supplemental Material, document 3 [84] for the companion-guided interview protocol). The interviewer also supported the participant and their personal contact in determining the best way to record the discussion. An in-person physical recording was offered and three different methods of recording an online conversation were discussed (Zoom; recording via phone; recording via Microsoft Teams). After completing the interviews; the participants shared the interview recording with the research team.

4. Focus group

After all participants completed at least two of the planned interviews, the interviewer reached out to schedule focus groups. The focus groups were different from the previous interviews in that the content of the interview was a reflection on students' experiences in the previous interview formats. Once again, both in-person or virtual interviews were offered. The focus group was designed to take no more than 1 h and was scheduled to have between 2 and 3 participants. The focus groups were conducted on Zoom and were also facilitated by running a Miro board (a virtual whiteboarding workspace) [86]. Prior to the scheduled time, the interviewer made a Miro Board that included several scales to rate the interviews along (e.g., "least enjoyable to most enjoyable" and "least supportive to most supportive"). The interview labels (i.e., oral, document, companion-guided) were placed on post-it notes on the Miro board, and in the interview, the participants were asked to place the post-its along the scale. The interviews were recorded and students had the option of turning on their video feed or only using audio (decided at the individual level, not group). Interview questions were provided at the time of scheduling the focus groups (multiple days prior to the focus group) without the Miro board specifics. (See Supplemental Document 4 for the focus group interview protocol.) There were no explicit norms discussed about responding via the chat on Zoom, but the interviewer did guide the conversation and directed turn taking, attempting to alternate who spoke. When working on the Miro board, the screen was shared with all participants and the interviewer moved the post-its in response to how participants described ranking the different interviews. At the end of the interview, the interviewer

again debriefed with participants about how these interviews might be used to improve the accessibility of future science courses.

C. Anticipation of variation

In this section, we show how we used the VPT to analyze each interview format and the anticipated load along the six dimensions of ability.

1. Oral interview

We considered a standard implementation of an oral interview to be that the interview is conducted verbally and lasts about 1 h. We anticipated that several aspects of a standard oral interview could have a high demand for various participants, as shown in Fig. 3. We predicted that an oral interview may be particularly taxing on the cognitive dimension because the participant is expected to maintain focus, remember questions, and provide quick responses. An oral interview could also be taxing on the physical/mobility dimension because the expected form of participation is speech and the participant is expected to fit in the interview setting (e.g., chair at a table) for the 1 h duration. At the same time, an oral interview could be taxing on the emotional/mental health dimension because the participant needs the energy to engage in the interview and to regulate their emotions during the length of the interview. A verbal interview anticipates that the participant is able to hear, and a 1 h interview expects that the person's health will allow them to regulate bodily systems for the length of the interview without a break.

The research team implemented some practices to mitigate these impacts. For example, the research team provided questions in advance, which mitigates the impact on hearing (by providing another form of access to the questions) and cognitive and emotional/mental health abilities (by providing additional time and modalities to process the questions). The participant was given the option to participate remotely or in person, which mitigates the impact on physical/mobility, emotional/mental health, and health dimensions by providing the participant autonomy over where the interview occurs, which can provide a more suitable physical environment and limits germ exposure. The research team further strove to mitigate the impact on emotional/mental health by giving the participant the autonomy to choose how the interview was recorded and by setting norms for skipping questions and debriefing, which provides the participant with autonomy about the questions discussed and support for difficult emotions that may have emerged.

The research team could have used closed captioning to further mitigate load on the hearing dimension, and they could have set norms for taking breaks to mitigate load on the physical, health, emotional/mental health, and cognitive dimensions.

2. Document interview

We anticipated that the written, asynchronous interview had a reduced load as compared to the verbal interview across all dimensions shown in Fig. 4. Written participation does not require hearing. The ability to work on the interview in a chosen space provides autonomy for the participant to select a space that meets their physical/mobility and health needs. The participants were given a suggested deadline of one week to complete the document interview; however, this was not an enforced deadline and more time was allowed if needed. This meant that participants could take breaks and engage on their own timescale, which creates a lower load on cognitive and emotional-mental health dimensions. The extended time frame of a week also allows time for the use of assistive technologies

VPT analysis — Oral interview

		Phys/Mob	Hearing	Visual	Emo/MH	Cog	Health
Interview structures	Verbal	High	High	Low	Medium	High	Low
	1 h.	Medium	Low	Low	High	High	Medium
Mitigation structures	Qs provided in advance		Mitigates		Mitigates	Mitigates	
	Remote optional	Mitigates			Mitigates		Mitigates
	Option to not record				Mitigates		
	Norms for skipping Qs/debriefing				Mitigates		

FIG. 3. Anticipated load for the oral interview structures and mitigating practices along the dimensions of ability in the VPT: physical/mobility (Phys/Mob), hearing, visual, emotional or mental health (Emo/MH), cognitive (Cog), and health.

VPT analysis — Document interview

		Phys/Mob	Hearing	Visual	Emo/MH	Cog	Health
Interview structures	Written	Low	Low	Low	Low	Low	Low
	Asynchronous	Low	Low	Low	Low	Low	Low
Mitigation structures	Microsoft Word			Mitigates		Mitigates	

FIG. 4. Anticipated load for the document interview structures and mitigating practices along the dimensions of ability in the VPT: physical/mobility (Phys/Mob), hearing, visual, emotional or mental health (Emo/MH), cognitive (Cog), and health.

like a screen reader or voice-to-text software, lowering the load on the visual dimension. The research team provided the document interview via a Microsoft Word document, which has built-in accessibility features [87] and typically allows for more customization than a PDF format [88], for example.

3. Companion-guided interview

We anticipated that the structured discussion with the participant-selected facilitator would have similar load as the oral interview on the physical/mobility, health, cognitive, visual, and hearing dimensions shown in Fig. 5. The ability to select the facilitator could mitigate these loads by providing the autonomy to select someone who uses the participant's preferred communication style (e.g., American Sign Language, supporting the hearing dimension) or who recognizes signs the person may need a break (e.g., supporting the cognitive and health dimensions). We anticipate that allowing the participant to select the person with whom they discuss the interview questions will reduce the emotional/mental health load by allowing the person to select someone with whom they are emotionally comfortable.

4. Focus group interview

Overall, we expected the focus group interview will create a similar load as the individual interview on a majority of dimensions as seen in Fig. 6. The focus group could have increased load on cognitive and emotional/mental health because the participant has to navigate the social participation, remember the question and their thoughts. A focus group could also increase the load on

VPT analysis — Companion-guided interview

		Phys/Mob	Hearing	Visual	Emo/MH	Cog	Health
Interview structures	Verbal	High	High	Low	Low	High	Low
	1 h.	Medium	Low	Low	Low	High	Medium
Mitigation structures	Participant-Selected Companion		Mitigates	Mitigates	Mitigates	Mitigates	Mitigates
	Remote Option	Mitigates					Mitigates
	Qs provided in advance		Mitigates		Mitigates	Mitigates	

FIG. 5. Anticipated load for the companion-guided interview structures and mitigating practices along the dimensions of ability in the VPT: physical/mobility (Phys/Mob), hearing, visual, emotional or mental health (Emo/MH), cognitive (Cog), and health.

VPT analysis — Focus group interview

		Phys/Mob	Hearing	Visual	Emo/MH	Cog	Health
Interview structures	Verbal	High	High	Low	Medium	High	Low
	1 h.	Medium	Low	Low	High	High	Medium
	Multiple participants	Low	Low	Low	High	High	High
	Miro whiteboard	Low	Low	High	Low	Mitigates	Low
Mitigation structures	Remote option	Mitigates			Mitigates		Mitigates
	Norms for participation				Mitigates		

FIG. 6. Anticipated load for the focus group interview structures and mitigating practices along the dimensions of ability in the VPT: physical/mobility (Phys/Mob), hearing, visual, emotional or mental health (Emo/MH), cognitive (Cog), and health.

the health dimension through increased germ exposure. The research team eliminated this load by offering a remote option for the focus group. The research team made use of the Miro whiteboard, which could increase load on the visual dimension because there is visual information to process, while simultaneously decreasing load on the cognitive dimension by providing an alternate form of communication.

The research team mitigated the possible increased load on the cognitive and emotional/mental health dimensions by providing norms for participation, which allowed participants to know when they were going to talk. They could have further mitigated the impact on emotional/mental health and cognitive dimensions by providing norms for communicating via chat.

Overall, we expected that the document interview creates the fewest barriers to participation and the focus group creates the most. However, we note that the document interview has the least external accountability, which may create new cognitive and emotional/mental health load on executive functioning skills.

V. WHAT DOES IT LOOK LIKE WHEN WE PLANNED FOR VARIATION IN OUR INTERVIEW STUDIES?

In this section, we now describe the methods and results of our study, particularly focusing on the effects of the different interview formats on disabled participants. We purposefully chose to focus this study on only disabled students' experiences. This choice is in alignment with standpoint theory, which asserts that there is more to learn from those who are not centered in a system (those with less power) than those who are members of dominant groups [89–91]. Mahowald summarizes Hartsock, saying "Members of the non-dominant groups, she [Hartsock] maintains, are capable of seeing beneath the surface of the social relations they experience, and the standpoint thus achieved allows them to see beyond present structures to possibilities that the members of the dominant group, which designed the structures according to their lights, are unable to vision" [89–91]. In our context, this means that the perspectives of disabled students are critical to examining the existing structures within interviews and postulating improvements beyond what able-bodied students as the dominant group would highlight. This is consistent with work focusing on other minority groups, including critiques of studies that compare women to men [92] as well as comparing Black students to White students [93]. Thus, we highlight disabled students' experiences and attitudes about the different interview types in this study.

A. Recruitment

Disabled students were recruited from multiple, active-learning physics courses at a large, research active institution in the United States. Announcements were made in class regarding the study, and classwide emails were sent inviting students to participate in a study to understand the experiences of disabled students in a variety of course formats and research formats. The recruitment email described that students would be asked to engage in 1 to 4 interviews about their experiences with disabilities in college environments and briefly described the interview formats. A $30

incentive was offered for participation in each interview format.

Participants were self-identified disabled students. There was no requirement to be formally registered with the local Office of Disability Services or to present any documentation on the impairment. Interested participants filled out a brief Qualtrics survey providing additional information, including questions about group-based courses they were enrolled in, their interest in participating in interviews, and any accessibility needs that might make their participation easier. (Note that the only accessibility request made by a participant was for virtual interviews.) Participants were also invited in the survey to describe their disability or impairment to the extent they felt comfortable.

Thirteen students responded to the Qualtrics survey. Of those 13 students, 8 described a disability or impairment and also indicated that they had experience with a group-based course in college. All 8 of those students received an email invitation to participate in an oral interview, which could take place in-person or over Zoom. Of those 8 students, 3 students participated in the initial oral interview. An additional two students were added to the sample through direct invitations based on previous connections with members of the research team. At the end of the oral interview, the following three interviews (document, companion-guided, and a focus group) were described and all five students were invited to participate in the subsequent interviews. Three students completed all of the interviews in the study design (two from the original recruitment and one from a direct invitation). As a result this paper focuses on these three students (described further in Sec. V C 1) and their experiences in the various interviews.

B. Interview implementation

In Sec. IV B, we described the methods and actions of the interviewer in the different interview formats; here, we highlight a couple of key aspects from the actual implementation. First, while an in person option was offered for all the interviews (except the document interview), all participants selected the virtual option. Thus, all our interviews were conducted over Zoom. Second, each focus group was scheduled to have between 2 and 3 participants. Unfortunately each focus group had 1 person who did not show up and so the focus groups were actually 2 and 1. Since we did not analyze the format of the focus group and only used the interview for participants' insight on the other formats, we do not believe that this has compromised the study. Finally, we should note that all interviews were conducted by an experienced qualitative interviewer (V. S.), with one oral interview being conducted by H. C. with V. S. in support. It is possible that having V. S., who conducted the majority of the individual interviews, conduct the focus group interviews led students to withhold some negative evaluations of the individual interview. On the other hand, it is possible that having V. S. conduct both interviews increased student comfort during the focus group interview, which may have supported them to share more of their perspectives.

C. Analysis choices

In the larger project, we had two primary goals: (1) an analysis of how different research interview techniques might impact the accessibility of the interview for participants and (2) a content analysis of the experiences of students who identify with a disability or impairment. Similarly, our analysis took a twofold approach. First, we analyzed the interview data using the VPT and highlighted ways that the planned interview format was enabling, mitigating, or disabling for the participant along the different dimensions of ability. Second, we analyzed the interview data generated with these participants for evidence of how they experienced courses as well as how they experienced the interviews. This paper focuses primarily on the first analysis though it is influenced by the analysis of how students experience courses. In this section, we briefly outline our approach to each of these analyses and describe the study participants.

1. Participants

Three students participated in all four interviews. All three of these students self-identify as a student with attention deficit-hyperactivity disorder (ADHD). We refer to these participants as participant B, participant J, and participant K and subsequently introduce each of them.

PARTICIPANT B: Participant B was a second-year student at the time of the interview and uses he/his pronouns. He is a transfer student to the large university from a nearby, urban community college, and he is majoring in applied engineering. Participant B identifies with the inattentive form of ADHD and was diagnosed in high school while displaying symptoms throughout childhood. While he received formal accommodations for his ADHD in high school, he has not pursued any formal accommodations or support from any institutions of higher education. He also does not identify ADHD as a disability as he believes that this is a limiting mind frame. His main symptoms are that he struggles with are inattention, lack of focus, problems with memory, and procrastination. He also struggles with online or asynchronous education and expresses a strong dislike for these class types. Participant B states that he has had positive experiences with physics courses at the large university, as well as the group work that is associated with those courses.

PARTICIPANT J: Participant J identifies as a person with a disability who uses he/him pronouns. He resonates mostly with the attention deficit portions of ADHD. His symptoms include issues with time management, test anxiety, organization problems, forgetfulness, and trouble communicating with others. He is formally registered with the Office of Disability Services on campus, and his

accommodations include extra time for exams and quizzes, separate testing space, and the ability to record lectures (though he does not use this accommodation). Participant J reported mixed experiences with group work. He described negative experiences with group work when his group members would move on without him, and he would feel too anxious to ask questions or ask for help. He also noted negative experiences with professors about lack of communication when discussing his accommodations or not showing a clear understanding of how those accommodations will reflect in his current classes. He reported some positive impacts of group work, such as the feeling of not being alone when confused and sharing the work load for large projects.

PARTICIPANT K: Participant K was a second-year transfer student at the time of the interview who uses she/her pronouns and is majoring in neuroscience. Participant K states that she "deals with" ADHD and depression. She was diagnosed in her first year at the large, 4-year university. Her ADHD presents as struggles with time management, getting distracted easily, fidgeting, and forgetfulness. Participant K's depression manifests as low mood and energy and struggles with attendance. She reached out for accommodations immediately after diagnosis and is formally registered with the Office of Disability Services on campus. Her accommodations include extended testing time, a separate testing space, extensions on assignments, and excused absences from class. She views these as helpful, but still finds that it is easy to fall behind. For her physics course, participant K expresses positive experiences with group work, such as reduced stress for deadlines and help with distribution of work. However, she does prefer to work alone.

2. Analysis process

The analysis of these interviews took a case study approach where the analysis of each participants' experience was led by a different undergraduate researcher (R. L, A. R., and H. C). The analysis process began with using a transcription service to generate written transcripts of each of the verbal interviews (oral, companion-guided, and focus group). Each research lead then carefully read through the transcripts following a content-analysis framework [94]. The content analysis followed the design of the interviews with categories for how participants described their disability or impairment, how they experienced coursework, group work, and laboratory work in science classes, and what barriers and supports they experienced in coursework. As each research lead developed an overview of the case [95] and was able to describe broadly the participants' experiences, the analysis moved to comparing the different interview formats inductively within a case. The analysis then turned to a more deductive approach, examining the interviews with each case and each interview format for evidence of how the interview structures were enabling, mitigating, or disabling for each participant along the dimensions of ability in the VPT. To operationalize this process, we considered how the enactment of the interview and the choices made in the moment by the interviewer enabled, mitigated, or disabled the participant's full participation.

In order to make claims about how the interview structures enabled or disabled participants, we used (i) the content of the focus group, which asked participants to reflect on the interview formats explicitly, and (ii) meta-comments reflecting on the interviews and triangulation of student experiences with interview experiences. In other words, the content of these interviews centered on students' experiences in the classroom and in school. Thus the analysis of how the interview enabled, mitigated, or disabled the student's participation at times relied on interpretations they made in comparison across interviews (in the focus group for instance) as well as triangulation of statements made in describing their experiences as a student. For example in the focus group interview, participant B described the document interview as "it felt more like I was doing homework, sort of. Or it felt like almost a chore, I guess" (participant B, focus group, page 2). In other contexts participant B described homework as an activity that is disabling for him with his struggles for motivation and focus. "Also, like when I'm not in classes, sometimes I struggle to like still be motivated to do my homework and to study" (Participant B, Companion-guided, page 6). Thus, when participant B describes the document interview as like homework, we coded that statement as disabling in ways similar to how independent homework is a disabling activity in a coursework setting.

D. Results

In the section that follows, we describe how the different interview styles played out for the three students with ADHD. Figure 7 shows the results for how each of the three participants experienced the oral, document, and companion interviews. The focus group interview is not included in the table because it focused on comparing the experiences of the three previous interviews. Because there is no "one size fits all" ideal interview for all participants, we discuss the results for each participant individually.

While we set out to code whether the interview environment was enabling, mitigating, or disabling across each dimension of ability, we quickly found that our data did not lend itself for analysis of the physical/mobility, hearing, or visual dimensions of ability. In other words, our participants did not describe advantages, barriers, or mitigation structures along these dimensions of ability. These dimensions were not explicitly probed in the interviews, nor did they come up naturally in response to the other questions. Rather than making weak claims along these dimensions, we narrowed

Participant	Interview type	Emo/MH	Cog
Participant B	Oral	Mitigating	Mitigating
	Document	Disabling	Disabling/ mitigating
	Companion	Mitigating	Disabling
Participant J	Oral	Disabling/ mitigating	Disabling
	Document	Mitigating	Disabling/ mitigating
	Companion	Mitigating	Disabling
Participant K	Oral	Mitigating/ enabling	Mitigating
	Document	Misabling	Disabling/ mitigating
	Companion	Mitigating	Disabling

FIG. 7. Summary of interview results for Participants B, J, and K along the cognitive (Cog) and emotional or mental health (Emo/MH) dimensions.

our analysis attention to the emotional/mental health and cognitive dimensions of ability.

As seen in Fig. 7, it was rare that students experienced any of the interview formats as enabling. Yet, we felt that it was important to capture this code as it is possible that an interview environment could directly align with a participants emotional/mental health and cognitive abilities in such a way that the format actually enabled their participation. This category also allowed us to think about ways that interviews could move into a more enabling space for participants. Rather than enabling students, it was much more common for the interview environment to mitigate disabling practices.

1. Participant B

Participant B largely experienced the document interview as disabling and the other two interview formats (oral and companion-guided) as mitigating an otherwise disabling situation.

Participant B directly described his dislike for asynchronous classwork in the focus group interview and the companion-guided interview, saying that asynchronous work leads him to "get very easily distracted by lots of things." In the focus group he then relates the document interview to asynchronous work saying, "it felt more like I was doing homework, sort of." Likening the document interview to homework and describing how asynchronous work leads him to "get very easily distracted by lots of things" points to how this asynchronous document interview was disabling for B along the cognitive dimension of ability. He described the document interview as "unenjoyable," adding that it was made unenjoyable because it was "difficult understanding what the question was asking." The combination of these two evaluations indicates the document interview was disabling for B along both the emotional health and cognitive dimensions of ability. However, B did also describe that the document was also mitigating on the cognitive dimension because he was able to "... include as much detail as I wanted. And it wasn't like there was a time limit on it."

Similar to the document interview, in the oral interview participant B described that he was concerned about misinterpreting the questions, but that this environment was mitigating along the cognitive dimension of ability because of the possibility of clearing up any confusion. B describes how, "The [oral] interview was the most supportive because any confusion I had about the questions could be cleared up on the spot allowing me to answer the questions to the fullest extent." Along the emotional/mental health dimension B also describes the oral interview as mitigating because in talking with someone else it was, "... very easy to make sure that what I'm saying isn't giving... misinterpreted."

Participant B experienced the companion-guided interview as a style that mitigated struggles along the emotional and mental health dimension of ability. He described a certain level of comfort with this interview style that was unique compared to other styles, including the chance to speak about topics that the participant had not had the chance to speak about recently saying, "I feel like I might have said some things that were things that I hadn't thought about in a long time..." He also described the companion-guided interview, which he completed with his mother, as the one he "enjoyed that one because I was just talking with my mom. It didn't really even seem like an interview so much as just like a conversation that I was having with my mom, which I enjoy."

2. Participant J

As shown in Fig. 7, participant J experienced the oral interview as disabling and the other two interviews as a mix of mitigating and disabling.

When describing the oral interview, J described having a difficult time remembering questions asked and forming answers on the spot, "It's harder for me to answer longer questions because it's easier for me to get lost as the person is talking. So the more time it takes for someone to ask me a question, the more opportunity there is for me to get lost." The difficulty to keep track of the question and then in turn experiencing, "a big struggle for me with like verbalizing my answers," in the oral interview suggests that format was disabling along the cognitive dimension. In the emotional/mental health dimension J describes the environment as stressful particularly in having to converse with a stranger.

J then notes the interviewer mitigated some of this stress, "I do think [the interviewer] did a really good job in making sure that I was comfortable in spite of the stress."

While the document interview mitigated the cognitive load by providing time to think about and revise answers, it was disabling because J had to plan time to complete the document asynchronously. J describes the mitigation of the cognitive load repeatedly by noting the time they had to think about and revise their answers saying, "I had time to reword, revise, change and make things make more sense." Yet J also describes the interview format as disabling along the cognitive and emotional/mental health dimensions when he says, "[the document interview] was more challenging to work into my schedule because with the verbal interviews, like with people over Zoom, like there was already a block of time spaced out and it wasn't really something that [was] in the air, like, it was like one hour of talking and that's it. So there wasn't much opportunity for it to get lost in everything else that I had to do, like for assignments and whatnot."

The companion-guided interview mitigated stress and pressure along the mental and emotional health dimension of ability for participant J. He spoke with his sister and he described this companion guided interview as, "it just felt more like a genuine conversation. And, there was just less pressure to like, say something that would make sense to someone I'm meeting for the first time." This was a significant difference for participant J who repeatedly noted that the Oral interview was uncomfortable due to talking with an unknown interviewer. However, there did appear to be disabling elements for the cognitive health dimension of ability as the participants had issues with focus during the interview describing, "we would go into those tangents so often it was, kind of, I guess I was always thinking about like, are we within the correct time limits."

3. Participant K

As shown in Fig. 7, participant K was the only participant to experience an interview format as enabling. The enabling experience in particular seemed to revolve around the reminders to participate in the interview. She says, "[I] really appreciate the reminder. I love reminders, that's why I responded so quickly because I was like, okay, this is a reminder that means do this now. That's a good thing for me." The love she expressed for the reminder system in place indicates that she experienced the interview as enabling along the emotion or mental health dimension of ability. However the interview was not without its difficulties including K describing, "the stress of talking to someone you didn't know for the first time." We coded this as mitigating along the cognitive and emotional/mental health dimensions of ability because K notes that there were elements of the interview format that were helpful. Specifically she describes that sending the questions ahead of time, "was very helpful" and that the format of the verbal interview, "allowed for more depth because there is an open discussion that allows further questioning with an immediate response."

Similar to participant B, participant K experienced the document interview as disabling because of the burden of having to interpret and understand questions on her own, describing answering questions in the "document interview was kind of just whatever I interpreted or I found important." Additionally she described how the document interview was disabling along the cognitive dimension because, "you kind of had to figure out a time on your own to complete it.... So, not having a scheduled time was something that I had to keep in mind." Yet, as the other two participants described, K agreed that the unconstrained time mitigated some of that stress because she had, "more time to organize my thoughts for a thoughtful response."

K experienced the companion-guided interview as mitigating for emotional health because it was similar to the oral interview but with the added benefit of being with someone she knew. In contrasting the three interviews she describes, "[companion-guided] was with someone whom you were able to choose, who you're comfortable with. [Oral] is more so a stranger, and then document is just about yourself." However, the interview was disabling due to having less structure. Again K contrasted the companion-guided with the oral interview saying, "the questions [in the companion-guided] weren't as specific or directed. Like with you [in the oral interview, the interviewer] were able to direct the conversation, ask questions in a very specific way."

VI. DISCUSSION

As shown in the results, we found that each participant had differing experiences in the separate interview styles, ranging from disabling to enabling. At this point, we do not attempt to build consensus across our participants as our goal is not to determine the "best" interview format. Instead, we emphasize the variation in our participants' experiences and that different interview structures helped support each of them in different ways. For example, for participant J, the stress of talking with a stranger was particularly impactful, and he found that the companion-guided interview mitigated that stress and pressure. For participant B, he was concerned about misinterpreting the questions and feeling like his answers may be misinterpreted; thus, he preferred the oral interview format since it was easier to make sure he was not misinterpreted. For participant K, the email reminders in particular enabled her to participate in the interviews and reduced the cognitive demand to remember and plan on her own. While the other participants were also sent reminders, for participant K, this structure in particular helped her to participate in the study. By offering alternative structures, formats, and supports, researchers allow participants to select a format that fits their needs, abilities, and interests. This is aligned with the

best practices from UDL, which emphasizes providing options and multiple means of engagement.

We found that the VPT was a helpful tool for thinking through the areas of our study design that might need alternatives or supports to enable participation. Thinking through each of the six dimensions allowed us to articulate the anticipated expectations for our participants and the level of load that we were expecting. In itself, this was a helpful exercise for us as a research team. That said, it is important to note that the anticipated loading on the VPT may not match the participants' experiences. For example, in our analysis, we had anticipated that the document interview would have a low load across all of the dimensions of ability and offered the fewest barriers to participation (see Figure 4). However, in discussion with our participants in the focus group, all the participants noted difficulties with finding a time to complete the document, planning the asynchronous work, and interpreting the questions on their own.

Furthermore, we would expect that participants' experiences would vary significantly depending on their particular disability or impairment. For instance, in the previous example, all of our participants noted the document interview as disabling due to the increased cognitive load; however, they each identified with having ADHD. A participant with a different disability or impairment might view the document interview as the most enabling out of the options. For example, a participant with severe social anxiety may prefer the document format as it does not require any face-to-face interaction. Alternatively, a participant who requires frequent breaks to manage their condition may prefer the document interview because of its flexible timing, rather than remain uncomfortable for an hour or frequently stepping out of the interview. Disability is not a monolith, and even a particular diagnosis does not pre-determine an individuals' abilities. All people (including disabled people) vary in their interests, needs, and abilities. Structures that may be enabling or mitigating for one person may be disabling for another. As our results show (summarized in Fig. 7), the interview experiences were different for each of our participants, even though they all identified as students with ADHD. This goes to show that while the VPT may be helpful in determining different alternatives, in the end, participants should be allowed to select the format that best works for them. Additionally, researchers should allow space in the recruitment process for participants to request their own supports or accommodations that the researcher(s) have not considered.

Finally, we would note that how the interview is enacted can be just as important as the interview structures themselves. When we say "enacted" here, we mean the way that the interview is carried out or the choices that the interviewer makes in the moment as they are carrying out the interview protocol. As participant J noted, "I do think [the interviewer] did a really good job in making sure that I was comfortable in spite of the stress." This shows that the interviewer took actions in the moment that mitigated the stress of the interview; however, these actions are rarely discussed or put into the interview protocol. While participant J did not expand on the actions taken by the interviewer to make him more comfortable, we could imagine that this includes tone of voice, how the interview procedures are explained, and how the participants' ideas are validated when shared with the interviewer. We expect that there are many actions that an interviewer takes in the moment that enable access for the participants.

VII. FUTURE WORK

Based on these results and limitations, there are many areas for future work in examining our our methodologies in PER. One potential avenue would be to investigate the disabling, mitigating, and enabling structures of interviews for participants with a wider variation of impairments. By happenstance, our participant volunteers all identified with ADHD; however, as already mentioned, we would expect that even the same structures would have different impacts for those with other types of impairments.

Another avenue for future work is to study the ways that interviewers enact the interviews. As participant J described, the ways that the interviewer interacted with him impacted his experience and made him feel comfortable in the interview environment. Similar to our previous work that highlights that there is more to teaching a curriculum than just the materials [96], there is more to conducting an interview than just the protocol. By studying *how* interviewers conduct interviews with disabled students, we can better articulate inclusive practices for other researchers.

There are also other interview formats to examine, beyond the three described in this study, that offer their own access considerations. For example, we would anticipate that focus group interviews would provide different results from a standard interview, such as challenges with managing cross-talk, which could be difficult for someone with a stutter or other form of speech impediment. Alternatively, having a peer in the interview could reduce the anxiety associated with talking one-on-one with a researcher. As another example, interviews that utilize other media to either stimulate recall or as artifacts within the interview (e.g., a video clip, an audio clip, a written document, cards to sort) present very different environments. For video information, there may need to be a verbal description of the video for someone with a vision impairment, or captions or a transcript of an audio clip for those with a hearing impairment. While we could not examine all interview formats in this study, we view this as an interesting line of investigation.

VIII. IMPLICATIONS FOR RESEARCHERS

We would like to conclude this paper with recommendations for mitigating and enabling strategies that

researchers may use when designing their studies, methods, and protocols.

First and foremost, we recommend that researchers use the VPT in their study design, particularly in examining their methods and data collection plans. As demonstrated in Sec IV C, we recommend starting with the "standard" form of data collection for the study and analyzing the expected abilities for that particular activity. For example, this means asking questions like "What am I expecting participants to be able to do?" or "How would someone with a visual impairment participate in this activity?" Once you have completed the VPT analysis, use the areas of high loads to brainstorm potential alternate formats that may reduce the load (while still achieving the study goals). When used as part of the study design, the VPT analysis can help research teams determine flexible alternatives and provide access for more participants in their studies.

Second, ensure that as a research team you provide a mechanism for requesting accommodations as a part of the recruiting process. For example, this could be an explicit statement in a recruitment email that says, "If you need any accommodations to participate in this study (i.e., an American Sign Language interpreter, adjusting format, etc.), please email Person X at emailx@college.edu. We are committed to providing equal opportunity for participation in this study and are happy to discuss modifications that can better suit your needs." Alternatively, if you are using a form (e.g., Qualtrics survey, Microsoft Form) for recruitment, consider adding a textbox that says "Please describe any practices that would make an interview [or study] more accessible for you (i.e., an American Sign Language interpreter, participating virtually or asynchronously, etc.)." We recommend providing examples of accommodations in these statements for clarity to your participants; further, we recommend using examples that you determined as viable from your VPT analysis.

Just as important, if any accommodations are requested, be sure to reach out to those participants about how their requests will be met. If you are unsure how to meet a request, we recommend asking the participant directly or working with your local Office of Disability Services to determine the best way to meet the request. Many universities have a wealth of resources through their Office of Disability Services, including access to assistive technology (like screen readers or captioning services), American sign language interpreters who work directly with the university, and extensive experience implementing accommodations.

Finally, we have compiled a list of recommendations specific to conducting interviews. This is not an exhaustive list, but rather represents what we have learned through this study either as a mitigation structure that we did offer in the current study or retroactively wish we would have offered. Not all of the strategies below may be applicable for every study design; however, we leave it to the researcher to decide what would be applicable to their study (rather than trying to delineate applications within this list). For each recommendation, we have included justifications from UDL guidelines along with the related guideline number or how the strategy might mitigate along a particular dimension of ability.

1. Send protocol questions to the participant ahead of the interview—this allows participants to think through answers in advance reducing the cognitive load and reduces reliance on processing auditory information (UDL 1.2: Offer alternatives for auditory information, UDL 6.2: Support planning and strategy development, UDL 6.4: Facilitate managing information and resources).
2. Schedule the interview for 10–15 min longer than anticipated to allow for clarification questions—allows participant time to clarify questions and reduces the cognitive and emotional/mental health load (UDL 6.4: Enhance capacity for monitoring progress).
3. Offer in-person and virtual options for participation —may reduce germ exposure (health dimension), reduce load on the physical and mobility dimension, and may allow for better use of assistive technology (e.g., use of Zoom closed captions). (UDL 4.2: Optimize access to tools and assistive technologies).
4. Offer to meet the participant prior to the interview to get to know one another—builds rapport and reduces the stress of meeting with a stranger and thus reducing load on emotional/mental health (UDL 7.3: Minimize threats and distractions).
5. For asynchronous work, offer to schedule a coworking time or a check in for accountability—supports participants in completing the work, reduces cognitive load on planning or scheduling (UDL 6.2: Support planning and strategy development, UDL 6.3: Facilitate managing information and resources).
6. Offer flexibility in interviewer, if possible—a participant-selected facilitator may make the participant more comfortable reducing load on emotional/mental health (UDL 7.3: Minimize threats and distractions).
7. Provide rough guidelines and a potential list of follow up questions if using a participant-selected facilitator—provides the participant and facilitator with expectations and reduces cognitive load in responding to questions (UDL 8.1: Heighten salience of goals and objectives).
8. Provide multiple opportunities for scheduling and send reminders—reduces cognitive load for the participant (UDL 6.2: Support planning and strategy development, UDL 6.3: Facilitate managing information & resources, UDL 7.3: Minimize threats and distractions).
9. Turn on closed captioning—allows alternative for auditory information (UDL 1.2: Offer alternatives for auditory information).

10. Offer choice in what data is recorded in the interview (audio only, audio & video)—allows autonomy in the interview process and reduces stress in the interview, creating a lower load on emotional-mental health (UDL 7.1: Optimize individual choice and autonomy, UDL 7.3: Minimize threats and distractions).
11. Offer breaks in the middle of the interview or discuss how a participant may ask for a break midinterview —reduces demand on health and emotional/mental health (UDL 7.1: Optimize individual choice and autonomy, UDL 7.3: Minimize threats and distractions).
12. Discuss norms for skipping questions or emphasize that the participant may skip questions and how they should indicate that—reduces load on emotional/mental health dimension by not requiring participants to answer questions they do not want to (UDL 7.1: Optimize individual choice and autonomy, UDL 7.3: Minimize threats and distractions).
13. Discuss norms for rephrasing questions or emphasize that the participant may ask for a question to be rephrased (UDL 7.1: Optimize individual choice and autonomy).
14. Discuss how follow-up questions may occur (interviewer will follow up in the moment, over email after the interview, etc.) and if the participant has a preferred method (UDL 7.1: Optimize individual choice and autonomy).
15. When there are multiple people, discuss norms for turn taking or indicate how the conversation will proceed—(UDL 8.3: foster collaboration and community).
16. Discuss norms for using the chat feature (e.g., in a virtual interview)—provides an alternate means for communicating their ideas (UDL 4.1: vary the methods for response and navigation).
17. Discuss what happens after the interview, including debriefing or post-interview support—reduce the emotion or mental health load, particularly if the interview topic is difficult for the participant (UDL 9.2: Facilitate personal coping skills and strategies).

We hope that this list aids researchers in reflecting on their own practices. In particular, we hope that this list helps researchers articulate their methods and how they carry out interviews. Protocols often do not communicate everything the interviewer does in an interview, and it can often be difficult to find a justification for why you have made an unconscious or reactive decision in an interview. We have found this list to be useful in articulating those justifications, in adjusting protocols when there is no justification, and in communicating good interview practices to new researchers. We view this as a useful learning exercise for new interviewers, experienced interviewers, and all those in between. We recognize that changing long-standing methods may be overwhelming; however, we would encourage researchers to take the data collection method they are most familiar with and simply try out a few variations or options that you could offer.

Ultimately, with this paper, we hope to inspire researchers to re-examine their research methods and implore researchers to plan for variation in participants' abilities in their study designs. In this study, we examined three different formats of interviews; however, we view this as a critical step for all research designs, qualitative or quantitative. While seemingly small, these options for participation provide better access to our research studies, making steps toward inclusion and addressing unexamined ableism in our work.

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[1] Nathan W. Moon, Robert L. Todd, David L. Morton, and Emily Ivey, *Accommodating Students with Disabilities in Science, Technology, Engineering, and Mathematics (STEM)* (Center for Assistive Technology and Environmental Access, Georgia Institute of Technology, Atlanta, GA, 2012), pp. 8–21.

[2] Erin Scanlon, Jillian Schreffler, Westley James, Eleazar Vasquez, and Jacquelyn J. Chini, Post-secondary physics curricula and Universal Design for Learning: Planning for diverse learners, Phys. Rev. Phys. Educ. Res. **14**, 020101 (2018).

[3] Erin Scanlon, Tamra Legron-Rodriguez, Jillian Schreffler, Elijah Ibadlit, Eleazar Vasquez, and Jacquelyn J Chini, Postsecondary chemistry curricula and universal design for learning: Planning for variations in learners' abilities, needs, and interests, Chem. Educ. Res. Pract. **19**, 1216 (2018).

[4] Scott Freeman, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt,

and Mary Pat Wenderoth, Active learning increases student performance in science, engineering, and mathematics, Proc. Natl. Acad. Sci. U.S.A. **111**, 8410 (2014).

[5] Lillian C. McDermott, Peter S. Shaffer *et al.*, *Tutorials in Introductory Physics* (Prentice Hall, Upper Saddle River, NJ, 2002).

[6] Lillian C. McDermott *et al.*, *Physics by Inquiry: An Introduction to Physics and the Physical Sciences* (John Wiley & Sons, New York, 1995), Vol. 1.

[7] Lillian C. McDermott *et al.*, *Physics by Inquiry: An Introduction to Physics and the Physical Sciences* (John Wiley & Sons, New York, 1995), Vol. 2.

[8] Edward F. Redish and Richard N. Steinberg, *Teaching Physics: Figuring Out What Works* (Educational Resources Information Center, 1999).

[9] Tutorials from the University of Maryland, Physics Education Group, http://physics.umd.edu/perg/tutorials.htm.

[10] Eric Brewe, Modeling theory applied: Modeling instruction in introductory physics, Am. J. Phys. **76**, 1155 (2008).

[11] Ibrahim Abou Halloun and David Hestenes, Modeling instruction in mechanics, Am. J. Phys. **55**, 455 (1987).

[12] Robert J. Beichner, Jeffery M. Saul, David S. Abbott, Jeanne J. Morse, Duane Deardorff, Rhett J. Allain, Scott W. Bonham, Melissa H. Dancy, and John S. Risley, The student-centered activities for large enrollment undergraduate programs (scale-up) project, *Research-Based Reform of University Physics* (2007), Vol. 1.

[13] Roberta Sullivan, Principles for constructing good clicker questions: Going beyond rote learning and stimulating active engagement with course content, J. Educ. Technol. Syst. **37**, 335 (2009).

[14] Christopher Keller, N. Finkelstein, K. Perkins, S. Pollock, C. Turpen, and M. Dubson, Research-based practices for effective clicker use, AIP Conf. Proc. **951**, 128 (2007).

[15] Mahmoud Kaddoura, Think pair share: A teaching learning strategy to enhance students' critical thinking, Educ. Res. Q. **36**, 3 (2013), https://eric.ed.gov/?id=EJ1061947.

[16] E. Etkina, D. T. Brookes, and G. Planinsic, The investigative science learning environment (ISLE) approach to learning physics, J. Phys. Conf. Ser. **1882**, 012001 (2021).

[17] Dimitra Kokotsaki, Victoria Menzies, and Andy Wiggins, Project-based learning: A review of the literature, Improv. Sch. **19**, 267 (2016).

[18] Paul W. Irving, Michael J. Obsniuk, and Marcos D. Caballero, P3: A practice focused learning environment, Eur. J. Phys. **38**, 055701 (2017).

[19] David Hestenes and Ibrahim Halloun, Interpreting the Force Concept Inventory: A Response to March 1995 critique by Huffman and Heller, Phys. Teach. **33**, 502 (1995).

[20] David Hestenes, Malcolm Wells, and Gregg Swackhamer, Force Concept Inventory, Phys. Teach. **30**, 141 (1992).

[21] Lin Ding, Ruth Chabay, Bruce Sherwood, and Robert Beichner, Evaluating an electricity and magnetism assessment tool: Brief electricity and magnetism assessment, Phys. Rev. ST Phys. Educ. Res. **2**, 010105 (2006).

[22] Karen Cummings, Jeffrey Marx, Ronald Thornton, and Dennis Kuhl, Evaluating innovation in studio physics, Am. J. Phys. **67**, S38 (1999).

[23] Ronald K. Thornton and David R. Sokoloff, Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the evaluation of active learning laboratory and lecture curricula, Am. J. Phys. **66**, 338 (1998).

[24] Richard R. Hake, Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses, Am. J. Phys. **66**, 64 (1998).

[25] Vashti Sawtelle, Eric Brewe, and Laird H. Kramer, Exploring the relationship between self-efficacy and retention in introductory physics, J. Res. Sci. Teach. **49**, 1096 (2012).

[26] Jayson M. Nissen and Jonathan T. Shemwell, Gender, experience, and self-efficacy in introductory physics, Phys. Rev. Phys. Educ. Res. **12**, 020105 (2016).

[27] Wendy K. Adams, Katherine K. Perkins, Noah S. Podolefsky, Michael Dubson, Noah D. Finkelstein, and Carl E. Wieman, New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey, Phys. Rev. ST Phys. Educ. Res. **2**, 010101 (2006).

[28] Bethany R. Wilcox and Heather J. Lewandowski, Students' epistemologies about experimental physics: Validating the Colorado Learning Attitudes about Science Survey for experimental physics, Phys. Rev. Phys. Educ. Res. **12**, 010123 (2016).

[29] Zahra Hazari, Gerhard Sonnert, Philip M. Sadler, and Marie-Claire Shanahan, Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study, J. Res. Sci. Teach. **47**, 978 (2010).

[30] Daryl McPadden and Eric Brewe, Impact of the second semester university modeling instruction course on students' representation choices, Phys. Rev. Phys. Educ. Res. **13**, 020129 (2017).

[31] Eugenia Etkina, Alan Van Heuvelen, Suzanne White-Brahmia, David T. Brookes, Michael Gentile, Sahana Murthy, David Rosengrant, and Aaron Warren, Scientific abilities and their assessment, Phys. Rev. ST Phys. Educ. Res. **2**, 020103 (2006).

[32] Elizabeth Evans Getzel, Addressing the persistence and retention of students with disabilities in higher education: Incorporating key strategies and supports on campus, Exceptionality **16**, 207 (2008).

[33] Nancy J. Evans, Ellen M. Broido, Kirsten R. Brown, and Autumn K. Wilke, *Disability in Higher Education: A Social Justice Approach* (John Wiley & Sons, New York, 2017).

[34] National Center for Science and Engineering Statistics, Women, minorities, and persons with disabilities in science and engineering, 2021 (National Science Foundation, Alexandria, VA, 2021), https://ncses.nsf.gov/wmpd.

[35] Tara Adam and Catharine Warner-Griffin, *Use of Supports Among Students with Disabilities and Special Needs in College* (National Center for Education Statistics, Washington, DC, 2022), https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2022071.

[36] Westley James, Caroline Bustamante, Kamryn Lamons, and Jacquelyn J. Chini, Beyond disability as weakness: Perspectives from students with disabilities, presented at

PER Conf. 2018, Washington, DC, 10.1119/perc.2018.pr.James.

[37] Westley James, Caroline Bustamante, Kamryn Lamons, Erin Scanlon, and Jacquelyn J. Chini, Disabling barriers experienced by students with disabilities in postsecondary introductory physics, Phys. Rev. Phys. Educ. Res. **16**, 020111 (2020).

[38] Westley James, Kamryn Lamons, Roberto Spilka, Caroline Bustamante, Erin Scanlon, and Jacquelyn J. Chini, Hidden walls: Stem course barriers identified by students with disabilities, arXiv:1909.02905.

[39] Kerrie Q. Baker, Kathleen Boland, and Christine M. Nowik, A campus survey of faculty and student perceptions of persons with disabilities, J. Postsecondary Educ. Disability **25**, 309 (2012), https://eric.ed.gov/?id=EJ1002143.

[40] Anne R. Thompson, Leslie Bethea, and Jennifer Turner, Faculty knowledge of disability laws in higher education: A survey, Rehabil. Couns. Bull. **40**, 166 (1997), https://eric.ed.gov/?id=EJ551683.

[41] Dalun Zhang, Leena Landmark, Anne Reber, HsienYuan Hsu, Oi-man Kwok, and Michael Benz, University faculty knowledge, beliefs, and practices in providing reasonable accommodations to students with disabilities, Remedial Spec. Educ. **31**, 276 (2010).

[42] Katherine Norman, Dana Caseau, and Greg P. Stefanich, Teaching students with disabilities in inclusive science classrooms: Survey results, Sci. Educ. **82**, 127 (1998).

[43] Tyler S. Love, Nicole Kreiser, Elsa Camargo, Michael E. Grubbs, Eujin Julia Kim, Penny L. Burge, and Steven M. Culver, STEM faculty experiences with students with disabilities at a land grant institution, J. Educ. Training Studies **3**, 27 (2015).

[44] Shanna K. Kattari, Examining ableism in higher education through social dominance theory and social learning theory, Innovative Higher Educ. **40**, 375 (2015).

[45] Jan Grue, The social meaning of disability: A reflection on categorisation, stigma and identity, Sociol. Health Ill. **38**, 957 (2016).

[46] Bruce G. Link and Jo C. Phelan, Conceptualizing stigma, Annu. Rev. Sociol. **27**, 363 (2001).

[47] Bruce G. Link and Jo Phelan, Stigma power, Soc. Sci. Med. **103**, 24 (2014).

[48] Stephen Kanim and Ximena C. Cid, Demographics of physics education research, Phys. Rev. Phys. Educ. Res. **16**, 020106 (2020).

[49] Jay T. Dolmage, *Academic Ableism: Disability and Higher Education* (University of Michigan Press, Ann Arbor, MI, 2017).

[50] A. Llewellyn and Kathleen Hogan, The use and abuse of models of disability, Disabil. Soc. **15**, 157 (2000).

[51] Inclusion London, The social model of disability, https://www.inclusionlondon.org.uk/about-us/disability-in-london/social-model/the-social-model-of-disability-and-the-cultural-model-of-deafness/ (2015).

[52] Tom Shakespeare *et al.*, The social model of disability, in *The Disability Studies Reader*, edited by L. J. Davis (Psychology Press, Routledge, 2006), pp. 197–204.

[53] E. Scanlon, M. Vignal, B. Wilcox, and J. Chini, Students' use of disability accommodations in emergency remote teaching, presented at PER Conf. 2021, virtual conference, 10.1119/perc.2021.pr.Scanlon.

[54] D. Goodley, *Dis/ability Studies: Theorising Disablism and Ableism* (Routledge, Taylor & Francis Group, London, 2014).

[55] Kirsten Brown, Edlyn Peña, Ellen Broido, Lissa Stapleton, and Nancy Evans, Understanding disability frameworks in higher education research, in *Theory and Method in Higher Education Research* (Emerald Publishing Limited, Bingley, 2019), pp. 19–36.

[56] R. K. Scotch, Medical model of disability, in *Encyclopedia of American Disability History*, edited by S. Burch (Facts on File, New York, 2009), Vol. 2, pp. 602–603.

[57] C. E. Drum, Models and approaches to disability, in *Disability and Public Health*, edited by G. L. Krahn, C. E. Drum, and H. Bersani, Jr (American Public Health Association, American Association of Intellectual and Developmental Disabilities, Washington, DC, 2009), pp. 27–44.

[58] Colin Barnes, *Disabled People in Britain and Discrimination: A Case for Anti-discrimination Legislation* (Hurst Co., London, 1991).

[59] James O. Bickford, Preferences of individuals with visual impairments for the use of person-first language, RE: view **36**, 120 (2004), https://www.proquest.com/docview/222958204/fulltext/1A3FEA51F5114219PQ/1?accountid=12598.

[60] Lydia X. Z. Brown, The significance of semantics: Person-first language: Why it matters, https://www.autistichoya.com/2011/08/significance-of-semantics-person-first.html (2011).

[61] Jim Sinclair, Why I dislike "person first" language, https://autismmythbusters.com/general-public/autistic-vs-people-with-autism/jim-sinclair-why-i-dislike-person-first-language/ (1999).

[62] Cara Liebowitz, I am disabled: On identity-first versus people-first language, https://thebodyisnotanapology.com/magazine/i-am-disabled-on-identity-first-versus-people-first-language/ (2015).

[63] ACCESS Project, Universal Design for Learning: A concise introduction., http://accessproject.colostate.edu/udl/modules/udl_introduction/udl_concise_intro.pdf (2011).

[64] U.S. Department of Housing and Urban Development, *Universal Design: Housing for the Lifespan of All People* (U.S. Department of Housing and Urban Development, Washington, DC, 1988).

[65] CAST, Universal Design for Learning guidelines version 2.2, https://udlguidelines.cast.org/ (2018).

[66] David H. Rose and Nicole Strangman, Universal design for learning: Meeting the challenge of individual learning differences through a neurocognitive perspective, Univ. Access Inf. Soc. **5**, 381 (2007).

[67] In previous articles, we called the tool "Dimensions of Ability Tool." We updated the language to better reflect our intended uses and interpretations.

[68] Erin Scanlon and Jacquelyn Chini, Ability profiles: A framework for conceptualizing dimensions of ability, presented at PER Conf. 2018, Washington, DC, 10.1119/perc.2018.pr.Scanlon.

[69] Robert Bogdan and Sari Knopp Biklen, *Qualitative Research for Education* (Allyn & Bacon, Boston, MA, 1997).
[70] Kathryn E. Newcomer, Harry P. Hatry, and Joseph S. Wholey, *Handbook of Practical Program Evaluation* (Wiley Online Library, 2015).
[71] James Calderhead, Stimulated recall: A method for research on teaching, Br. J. Educ. Psychol. **51**, 211 (1981).
[72] Heidi B. Carlone, Catherine M. Scott, and Cassi Lowder, Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science, J. Res. Sci. Teach. **51**, 836 (2014).
[73] Lettie Y. Conrad and Virginia M. Tucker, Making it tangible: Hybrid card sorting within qualitative interviews, J. Doc. **75**, 397 (2019).
[74] Bedrettin Yazan, Three approaches to case study methods in education: Yin, Merriam, and Stake, Qual. Rep. **20**, 134 (2015).
[75] Robert K. Yin, Discovering the future of the case study. method in evaluation research, Eval. Pract. **15**, 283 (1994).
[76] Anne Haas Dyson and Celia Genishi, *On the Case* (Teachers College Press, New York, 2005), Vol. 76.
[77] Sharon Vaughn, Jeanne Shay Schumm, and Jane M Sinagub, *Focus Group Interviews in Education and Psychology* (Sage, Newbury Park, CA, 1996).
[78] Lia M. Gray, Gina Wong-Wylie, Gwen R. Rempel, and Karen Cook, Expanding qualitative research interviewing strategies: Zoom video communications, Qual. Rep. **25**, 1292 (2020).
[79] Victoria Opara, Sabrina Spangsdorf, and Michelle K. Ryan, Reflecting on the use of google docs for online interviews: Innovation in qualitative data collection, Qual. Res. **23**, 561 (2021).
[80] Elaine Byrne, Ruairi Brugha, Eric Clarke, Aisling Lavelle, and Alice McGarvey, Peer interviewing in medical education research: Experiences and perceptions of student interviewers and interviewees, BMC Res. Notes **8**, 513 (2015).
[81] Saeeda Shah, The researcher/interviewer in intercultural context: A social intruder!, Br. Educ. Res. J. **30**, 549 (2004).
[82] Django Paris, a friend who understand fully: Notes on humanizing research in a multiethnic youth community, Int. J. Qualitative Studies Educ. **24**, 137 (2011).
[83] Brittany St. John, Iulia Mihaila, Katelyn Dorrance, Leann Smith DaWalt, and Karla K. Ausderau, Reflections from co-researchers with intellectual disability: Benefits to inclusion in a research study team, Intellect. Dev. Disabil. **56**, 251 (2018).
[84] See Supplemental Material at http://link.aps.org/supplemental/10.1103/PhysRevPhysEducRes.19.020143 for the protocols used in the four different types of interviews.
[85] Herbert J. Rubin and Irene S. Rubin, *Qualitative Interviewing: The Art of Hearing Data* (Sage, Newbury Park, CA, 2011).
[86] Miro, https://miro.com/.
[87] Microsoft, Improve accessibility with the accessibility checker, https://support.microsoft.com/en-us/office/improve-accessibility-with-the-accessibility-checker-a16f6de0-2f39-4a2b-8bd8-5ad801426c7f.
[88] Mireia Ribera Turró, Are pdf documents accessible?, Inf. Technol. Libr. **27**, 25 (2008).
[89] Mary Briody Mahowald, Our bodies ourselves: Disability and standpoint theory, Soc. Philos. Today **21**, 237 (2005).
[90] Nancy C. M. Hartsock, *The Feminist Standpoint Revisited, and Other Essays* (Routledge, 2019).
[91] Nancy C. M. Hartsock, *Money, Sex, and Power: Toward a Feminist Historical Materialism* (Northeastern University Press, Boston, MA, 1985).
[92] Adrienne L. Traxler, Ximena C. Cid, Jennifer Blue, and Ramón Barthelemy, Enriching gender in physics education research: A binary past and a complex future, Phys. Rev. Phys. Educ. Res. **12**, 020114 (2016).
[93] Danny Bernard Martin, Researching race in mathematics education, Teach. Coll. Rec. **111**, 295 (2009).
[94] Johnny Saldana, *Fundamentals of Qualitative Research* (Oxford University Press, New York, 2011).
[95] Frederick Erickson, Comments on causality in qualitative inquiry, Qual. Inq. **18**, 686 (2012).
[96] Daryl McPadden, Eric Brewe, Camila Monsalve, and Vashti Sawtelle, Productive faculty resources activated by curricular materials: An example of epistemological beliefs in university modeling instruction, Phys. Rev. Phys. Educ. Res. **16**, 020158 (2020).