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Making geoscience fieldwork inclusive and accessible for students with disabilities

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ABSTRACT

Fieldwork is a fundamental characteristic of geoscience. However, the requirement to participate in fieldwork can present significant barriers to students with disabilities engaging with geoscience as an academic discipline and subsequently progressing on to a career as a geoscience professional. A qualitative investigation into the lived experiences of 15 students with disabilities participating in a one-day field workshop during the 2014 Geological Society of America Annual Meeting provides critical insights into the aspects of fieldwork design and delivery that contribute to an accessible and inclusive field experience. Qualitative analysis of pre- and post-fieldwork focus groups and direct observations of participants reveal that multisensory engagement, consideration for pace and timing, flexibility of access and delivery, and a focus on shared tasks are essential to effective pedagogic design. Further, fieldwork can support the social processes necessary for students with disabilities to become fully integrated into learning communities, while also promoting self-advocacy by providing an opportunity to develop and practice self-advocacy skills. Our findings show that students with sensory, cognitive, and physical disabilities can achieve full participation in field activities but also highlight the need for a change in perceptions among geoscience faculty and professionals, if students with disabilities are to be motivated to progress through the geoscience academic pipeline and achieve professional employment.

INTRODUCTION

The geosciences are facing a dual crisis in terms of a pending shortage of qualified, professional geoscientists and a lack of diversity (Stokes et al., 2015). The geosciences have the poorest diversity record of all science, technology, engineering, and mathematics (STEM) fields (Gannet Hallar et al., 2010; Huntoon et al., 2015; Stokes et al., 2015), and the need to recruit to geoscience and other STEM disciplines from under-represented groups is well recognized (e.g., Levine et al., 2007; Sherman-Morris and McNeal, 2016). Several authors have investigated the "geoscience pipeline" in an attempt to map career trajectories from secondary (or pre-college) school to higher education and on into the workplace (e.g., Levine et al., 2007; Gonzales and Keane, 2009; Houlton, 2010; LaDue and Pacheco, 2013). While a number of these projects have focused on specific aspects of diversity such as race and/or ethnicity (e.g., Gannet Hallar et al., 2010; Stokes et al., 2015; Carrick et al., 2016) and gender (e.g., Canetto et al., 2012; Stokes et al., 2015), little attention has been paid to learners with disabilities. Yet learners with disabilities represent a talented population with a diverse perspective of the natural environment and the same potential to become expert, professional geoscientists.

Geoscience is a challenging subject in its own right, but the requirement to undertake fieldwork in addition to rigorous academic study presents particular issues for students with disabilities (Gilley et al., 2015). Professional geoscientists work in a wide range of environments (AGI, 2019), and there are many viable geoscience career paths that are laboratory-based or that involve modeling, "big data" applications, or remote sensing; these career paths do not involve fieldwork or the crossing of long distances of uneven terrain on foot (Cooke et al., 1997). However, the majority of undergraduate geoscience programs require students to undertake a component of field learning (Drummond and Markin, 2008; Petcovic et al., 2014). Indeed, in the UK, it is mandated by the Quality Assurance Agency that students graduating from programs in geography, Earth science, and environmental science must have completed a component of fieldwork (QAA, 2014a, 2014b). In addition, the Geological Society of London, the main accrediting body for undergraduate degree programs in the United Kingdom, specifies a minimum number of field days that students must complete (up to 60 days, depending on the program) (The Geological Society, 2012). Other jurisdictions, e.g., British Columbia, have similar fieldwork requirements that need to be met for professional registration (e.g., APEG, 2012). Students opting to study or major in geoscience programs must therefore expect to spend some time learning in field environments.

This requirement for fieldwork presents an interesting scenario. The geosciences need more talented and committed graduates to ensure a future supply of professionals to the workforce; yet a critical—and typically compulsory—component of undergraduate geoscience education presents physical and psychological barriers that can preclude learners with disabilities, i.e., talented potential scientists, from engaging with the discipline in the first place. In the United States, only 11% of undergraduate students with declared or documented disabilities are majoring in STEM subjects (Ellis et al., 2007, cited in Atchison and Libarkin, 2016), while in the United Kingdom, 14% of physical sciences undergraduates have a declared disability (Advance HE, 2018). All learners should perceive geoscience as an accessible academic subject with viable career options, irrespective of the requirement to spend time in the field. Indeed, Mogk and Goodwin (2012) argue that some cognitive and affective gains can only be acquired through immersive field experiences that cannot be replicated though virtual fieldwork or "alternative" (i.e., non-field-based or non-immersive) activities. If fieldwork is a perceived barrier to access and engagement for learners with disabilities, then we need to identify how to modify fieldwork design and delivery and, more importantly, learner and practitioner perceptions, in order to overcome this barrier and ensure that *all* students are able to participate and share in formative learning experiences. This study presents findings from a qualitative investigation into the experiences of students with disabilities participating in a field-based workshop designed to be physically and socially accessible and inclusive and makes recommendations for the design and delivery of future geoscience fieldwork.

Challenges Presented by Fieldwork for Students with Disabilities

Under the UK Equality Act (2010), a person has a disability if they (1) have a physical or mental impairment, and (2) the impairment has a substantial and long-term adverse effect on their ability to carry out normal day-to-day activities. Similarly, the U.S. federal government defines a person as having a disability if they (1) have a physical or mental impairment that substantially limits one or more "major life activities"; (2) have a record of such an impairment; or (3) are regarded as having such an impairment (https://www.dol.gov/odep/faqs/general.htm). Despite these seemingly clear definitions, however, the term "disability" is open to wide interpretation, and faculty can struggle to identify "what counts" in terms of designing inclusive and accessible geoscience curricula (Feig et al., 2019). A further complication identified by Feig et al. (2019) is that communication between instructors and college and/or university disability services offices is often one-way and proscriptive. The disability services office documents a student's disability and proscribes accommodations. The geoscience instructor thus has little opportunity to define, for his or her own self, what constitutes "disability."

While many practitioners might perceive geoscience fieldwork in terms of physically rigorous mapping camps, the types of field activities that geoscientists undertake vary in range and scope depending upon the learning goals and the kinds of exercise that will enable those goals to be met (see Whitmeyer et al., 2009, and references therein). To date, however, limited attention has been paid to the design of fieldwork that is accessible and inclusive for learners with disabilities (Bennett and Lamb, 2016; Carabajal et al., 2017, but see Healey et al., 2001). Cooke et al. (1997) describe the design and delivery of two accessible geoscience field trips and one hypothetical field exercise to support the learning of students with mobility impairments. Asher (2001) describes accommodations made to an introductory geology course, which included fieldwork, for a student with impaired vision. A key finding from these studies was that, rather than compromising academic merit, revisions made to accommodate students with disabilities can potentially enhance the course for all learners. Broader issues relating to physical accessibility are explored by Nairn (1999) in relation to physical geography fieldwork. Nairn states that "field-trip culture is based on taken-for-granted notions that everybody is physically able" (p. 274), thereby implying that perceptions of disability can extend to a lack of physical fitness (see also Maguire, 1998; Feig, 2010). Since fieldwork emphasizes action, Nairn argues that the knowledge gained from fieldwork is "physically encoded," and thus that students with mobility and sensory disabilities are "excluded from particular forms of [geographic] knowing" (p. 278). This concept of "embodiment," whereby learning emerges from interactions between the learner and the physical and social spaces in which they work, has also been described specifically in relation to geoscience fieldwork (Mogk and Goodwin, 2012). Maguire (1998) further acknowledges the need to reconstruct undergraduate field experiences to better reflect the diversity of the student community and move away from the image of fieldwork as a "character-building rite of passage."

The learning experiences of students with disabilities majoring in geography, Earth science, and environmental science are further explored in empirical studies by Hall et al. (2004) and Hall and Healey (2004, 2005). While fieldwork did not emerge as a concern for these students prior to starting at university, four main barriers to participation were identified: (1) physical mobility and negotiation of fieldwork sites; (2) removal of the student from familiar environments and support structures; (3) the need to make significant adjustments to everyday activities in the field; and (4) issues relating to reading, note-taking, and organization required for individual fieldwork (Hall and Healey, 2005). These findings indicate that students with disabilities were most likely to face barriers relating to independent fieldwork, as opposed to group activity undertaken either over a single day or a multi-day residential field course.

In order to obtain appropriate and effective support for field activities, students with disabilities must be willing and able to self-advocate for their needs (Hendricks et al., 2017). Self-advocacy is defined here as the ability to speak up for oneself and one's needs. It has been linked to improved retention and success among learners, and it is widely seen as an important skill for students with disabilities to develop (Test et al., 2005; Roberts et al., 2016, and references therein). The ability to self-advocate effectively can be particularly important for students with disabilities transitioning into adult life and moving into employment (e.g., Lindstrom et al., 2011). However, in a recent literature review, Roberts et al. (2016) identified that, to date, few studies into the development of self-advocacy skills among learners with disabilities have taken place outside of the classroom (Roberts et al., 2016). Hendricks et al. (2017) previously explored the impact of fieldwork on self-advocacy among students with disabilities, focusing specifically on the use of personal assistants for students with visual and hearing impairments participating in the field workshop described in this paper. Their findings revealed varying degrees of comfort among the students studied in self-advocating for their needs, influenced by multiple factors including prior experiences and their individual personalities. Our study therefore presents an opportunity to both expand the work of Hendricks et al. (2017) and generate insights into the wider potential for fieldwork for promoting self-advocacy.

While previous investigations into the experiences of students with disabilities consider the "mechanics" of fieldwork (e.g., Cooke et al., 1997; Hall et al., 2004; Hall and Healey, 2004, 2005), they do not explicitly consider learners' social experiences. Social connectivity has been identified as an important "informal" outcome from undergraduate fieldwork (Fuller, 2006; Stokes and Boyle, 2009; Streule and Craig, 2016), and a key opportunity afforded by fieldwork is the creation of learning communities whereby active and experiential learning is encouraged through social interaction and collaboration between groups of learners (Wilson and Ryder, 1996; Cross, 1998; Zhao and Kuh, 2004; Skop, 2008; Walsh et al., 2014). Learning communities include specific characteristics that make this approach particularly suited to geoscience fieldwork: distributed control of learning, flexible and negotiated learning activities, pursuit of a common purpose, the generation and sharing of knowledge, autonomy among community members, and feedback loops driven by dialogue, interaction, and collaboration (Wilson and Ryder, 1996). When instructors participate in learning communities, they become facilitators rather than leaders (Cross, 1998; Sugerman, 2001), providing the focus for group-related tasks that foster formal and informal communication between students and faculty (Skop, 2008). Building learning communities through fieldwork can yield positive outcomes, particularly in terms of peer and student-faculty engagement and empowering students to become active learners (Walsh et al., 2014). Gaining further insight into social experiences and considering the social context of inclusion within accessible fieldwork are therefore important areas of concern for this study.

Wider Issues Faced by Students with Disabilities in Higher Education

Prior research into the lived experiences of students with disabilities has yielded critical insight into the ways in which multiple barriers to access and inclusion in higher education are negotiated (e.g., Borland and James, 1999; Fuller et al., 2004a, 2004b; Vickerman and Blundell, 2010; Madriaga et al., 2011; Gibson, 2012; Magnus and Tøssebro, 2014). A range of data generation methods, mainly qualitative, have previously been used to investigate the learning experiences of students with disabilities. Approaches include individual interviews (Vickerman and Blundell, 2010; Gibson, 2012; Magnus and Tøssebro, 2014), focus groups (Fuller et al., 2004b; Magnus and Tøssebro, 2014), and personal reflections (i.e., diaries) (Magnus and Tøssebro, 2014). Quantitative surveys are less frequently encountered in studies of this type, examples being Fuller et al. (2004a), Vickerman and Blundell (2010), and Madriaga et al. (2011). This arguably reflects the need for qualitative approaches to generate the rich descriptions required to gain insight into the highly iterative and unpredictable nature of learning.

A common theme emerging from these studies is that practice should be inclusive for, and of benefit to, all students—not just those with disabilities. Achieving this inclusion means considering the social as well as academic processes that take place during learning. To reduce perceived social barriers, learners with disabilities may attempt to hide or downplay their limitations in an attempt to appear "normal." This pursuit of "normalcy" among students with disabilities can result in feelings of low self-esteem and a lack of belonging. These feelings, in turn, can fuel a reluctance to ask for help and in doing so identify themselves as different (e.g., Fuller et al., 2004a). This is particularly so among students with unseen disabilities (such as dyslexia or mental health issues); for these students, passing as normal may appear a particularly viable—and desirable—option (Magnus and Tøssebro, 2014; Hendricks et al., 2017). Social processes and attitudes such as prejudice can also make learners with disabilities feel unduly pressured into disclosing impairments that they may prefer not to disclose (Madriaga et al., 2011) or deter them from disclosing a disability when applying to higher education for fear they will not be offered a place (Vickerman and Blundell, 2010). While such disclosure may be (or is very probably) necessary if students wish to gain the necessary support and negotiate individual adjustments within higher education (Magnus and Tøssebro, 2014), ultimately we should be looking to develop and promote socially just pedagogic practices in which such disclosure is simply not necessary in the first place (Madriaga and Goodley, 2010; Madriaga et al., 2011).

The social relationships developed by learners with disabilities can be particularly important to their overall experience of higher education. Learners with disabilities do not exist in isolation—they are participants in the same social processes of life as other learners, i.e., the need to learn with and from other people, and these processes are important to academic progress (Gibson, 2012). Gibson (2012) found that students with disabilities felt that their peers lacked appreciation for the whole spectrum of diversity, while practitioners may see themselves only as educators of "normal" learners, in a system that favors "normal" brain (and body) function. One means of addressing these issues is for the provision of disability support to be presented as "normal" to *all* students, not just those with impairments (Feig et al., 2019). Students with disabilities are present across all academic programs, irrespective of whether or not their disability is disclosed. Faculty therefore need to appreciate that their instructional methods affect all students and that designing instruction to be inclusive and accessible from the outset, e.g., by paying attention to pace and timing and incorporating opportunities for multisensory engagement, reduces barriers to all students engaging with learning communities.

Statement of Purpose

This study reports findings from a qualitative investigation into the experiences of students with disabilities participating in a physically accessible and fully inclusive geoscience field workshop. These findings have important implications for the design and delivery of future accessible and inclusive fieldwork. The following specific research questions are addressed:

1. What are the aspects of fieldwork design that contribute to an inclusive and accessible field experience for students with disabilities?
2. How does fieldwork design promote the development of learning communities?
3. How does participating in accessible fieldwork promote self-advocacy among learners with disabilities?

This study was conducted in correlation with a separate but related study, during the same accessible field workshop, exploring the interactions between faculty and students during accessible and inclusive fieldwork. The results from, and experiences of, geoscience faculty participating in this field study are reported in Feig et al. (2019).

METHODS

Research Approach and Theoretical Perspectives

Accessible field design requires an understanding of lived experiences of, and interpersonal processes between, participants. The best means of accomplishing this is through qualitative inquiry. The qualitative tradition allows the interpretation and analysis of human interaction, emotions, expressed sentiment and prior lived experience. The "data" in qualitative inquiry are generated through observation, conversation, and the construction of a narrative that relays a holistic view of lived experience. Fundamentally, humans are the focus of this study. Well-established methodologies in qualitative inquiry include ethnography, phenomenology, phenomenography, case study, and biography (Creswell, 2003). One might ask, "Why not use surveys?" While surveys can shed some light on accessibility, design, and base levels of both the emergence of learning communities and self-advocacy, they do not generate the on-the-ground data that illuminate human response to dynamic, real-time field experiences. While such methods are unfamiliar to most geoscientists, they are appropriate for non-geological, interpersonal phenomena of the type that take place in teaching and learning settings: because it is not the rocks we are studying—it is the people learning about them.

This study uses a phenomenological participant-action research approach to investigate the experiences of students with disabilities learning in a field environment. This approach involves participants and researchers working together in order to understand and change problematic situations. This is typically done by "embedding" the researcher in the study group as they go about the experience under study (Wolcott, 2001). Phenomenology is an exploration of the lived experiences of individuals. In this case, the experiences of students participating in fieldwork designed to be accessible and inclusive have been documented, analyzed, and interpreted as "results" (Robson, 2011). Furthermore, qualitative inquiry serves not to generalize to all possible populations, but rather provides an illumination (Creswell, 2003) for a (usually) local phenomenon. This illumination can inform the understanding of processes taking place at other locations and can also seed and drive subsequent quantitative, empirical inquiry. Further details about this approach are presented in Feig (2011) and Feig et al. (2019), the latter applying a similar approach to exploring the experiences of the faculty members participating in this field workshop.

The key theoretical perspectives applied to this study relate to sociocultural and social theories of learning. Rooted in the work of Vygotsky (1978), sociocultural theory provides a useful framework to consider the influence of social factors such as peer-peer and student-instructor interactions on learning and instruction. It is particularly suited to questions concerning the cultures—and related practices—existing within educational institutions (Gibson, 2012), and especially where these concern non-traditional or underrepresented groups. The social context of learning also forms the focus for the theoretical perspectives of Jean Lave and Etienne Wenger (e.g., Lave and Wenger, 1991; Wenger, 1998), who consider how learning is situated in authentic contexts, as well as the formation of communities of practice. The social interaction facilitated within field environments enables learners to construct knowledge and skills, and acquire a technical vocabulary, through collaboration with both experts and peers. Participating in authentic, situated inquiry enables learners to attribute meaning to their learning and start to develop their identity as members of a professional or expert geoscience community (Streule and Craig, 2016).

Study Site and Field Activity Design

The Geological Society of America (GSA) offers regular field excursions to geologically important locations as part of its annual meeting programs. The authors conducted a one-day field excursion during the 2014 GSA meeting in Vancouver, British Columbia, designed to promote field accessibility for geoscience students and faculty with disabilities. Under the premise of exploring the geology of the Vancouver region and engaging the abilities of all participants in the field, this excursion was designed to be a dynamic, workshop-style experience for non-disabled geoscience instructors: working directly with, and learning from, students and faculty with disabilities on how to best implement accessibility and inclusion in field-based teaching and learning. Planning for access and inclusion may include (but is not restricted to) consideration of how to identify and alleviate barriers to participation by designing purposeful content engagement in all activities collaboration as well as across the entire learning community. This strategy aligned with our research goals of improving field accessibility, as described in our results and discussion below.

During the field excursion, participating non-disabled faculty were paired with geoscience students and faculty who had previously self-disclosed various physical, sensory, social, and cognitive disabilities. Prior to departure, the logistical and pedagogical components of the day were discussed with the entire group, and participants were briefed on a set of ground rules: (1) participants were expected to support and advocate for themselves, each other,

TABLE 1. OVERVIEW OF FIELD LOCATIONS AND ASSOCIATED LEARNING ACTIVITIES

Location	Characteristics	Geology	Content focus	Learning activities
All locations			Multisensory description of the field location	Locate yourself on the location map. With your partner(s), use all of your senses, and record the things you notice about this site. What do you observe?
1. Stanley Park, Third Beach	Sandy beach with outcrop exposed along footpath on southern side	Wave and storm hazards, beach environment and coastal processes	Geologic and natural hazards; sedimentary processes	What hazards could affect this area? What are the characteristics of this location that make it particularly susceptible to wind?
2. Cypress Mountain lookout	Elevated viewpoint looking south over the Vancouver Bay area	Formation and geology of the Metro Vancouver Region	Identification of geologic hazards affecting urban area	Divide the Vancouver area into distinct regions based on the elevation of the land. Would landslides or earthquakes affect any one of your regions more than the others?
3. Porteau Cove	Waterfront recreational area providing views of surrounding fjord and landscape	Landslides, glaciers, and engineering	Geologic hazards; engineering geology techniques	Describe what makes this location susceptible to landslides. Describe the various landslide mitigation techniques observed in the area.
4. Garibaldi Park, Rubble Creek	Trailhead area with access to creek via footpath	Volcanic processes and landslides	Rock ID; landscape evolution	From the ground near the parking lot, select one rock sample for each person and describe it. Identify landscape features and describe how the area formed.
5. Stawamus Chief	Granite dome exposed at roadside location	Igneous intrusions and glacial erosion	Rock ID; large-scale igneous and glacial processes	From the ground near the parking lot, select one rock for each person and describe it. Describe the formation of glacial fluting. How do the rocks here compare to the previous location?

and for anyone who is experiencing difficulty; (2) because not everyone would be able to physically reach or experience all locations and in consideration of individual abilities, participants would designate someone to explore and bring back samples and observations for whole group discussions and interpretations; and (3) participants would offer to help before helping. Activity design components that promote access and inclusion are discussed in further detail throughout this paper and summarized in Table 1. Key outcomes from this field workshop focus on areas beyond the purview of this paper (summarized in Table 2), particularly field site selection and implementing strategies to include students with sensory (i.e., auditory and visual) disabilities in the community of learning during a field course and are described in further detail in Atchison and Gilley (2015), Gilley et al. (2015), Stokes and Atchison (2015), Hendricks et al. (2017), and Feig et al. (2019).

It should be noted that this field excursion was specifically designed as a workshop to enable students and faculty to work together and share their geoscience content expertise and field-focused accommodation strategies to broaden accessibility to the field content. This paper is not meant to serve as a generic course model to be replicated but rather as a way of demonstrating effective pedagogical practices and strategies for mitigating barriers and accommodating students with disabilities in geoscience field courses. Additionally, the findings of this field workshop are not only relevant to undergraduate students but can apply to a broad range of geoscience fieldwork including graduate student research activities, informal and public education experiences, and training for professional geoscientists.

Study Population and Setting

Fourteen geoscience faculty and 15 students participated in the field workshop, the latter forming the population for this study. Fourteen of the

TABLE 2. RELATED PUBLICATIONS DETAILING CONCRETE EXAMPLES OF PRACTICE

Reference	Fieldwork element described	Examples of practice
Atchison and Gilley (2015)	Planning and logistics	Creating learning materials in multiple formats (audio and visual); allowing down time during travel between locations; selecting locations with accessible outcrops and/or overviews; choosing locations with multiple sensory inputs (e.g., noise from an active river, an outcrop that has clear glacial polish and striations, etc.).
Gilley et al. (2015)	Planning and logistics	Developing community and comfort among participants prior to, during, and after the trip; selecting locations to accommodate the transport (e.g., an accessible bus).
Stokes and Atchison (2015)	Creation of learning communities	Involving faculty as co-participants and co-learners (i.e., pairing faculty with students).
Hendricks et al. (2017)	Use of personal assistants for learners with sensory impairments	Integration and purposeful placement of personal assistants to facilitate communication (e.g., have a sign language interpreter sit on the bus with a participant with impaired hearing).
Feig et al. (2019)	Faculty-focused planning and logistics	How to work with Student Disability Services Offices; setting expectations for field-based inclusion; alternatives to 'alternative' activities for students with disabilities.

15 students self-identified as having some kind of physical (n = 7), cognitive (n = 3), or sensory disability, e.g., hearing (n = 1) or vision-impaired (n = 3), although during post-fieldwork discussions, it emerged that the fifteenth student had previously suffered injuries that significantly limited her physical mobility, and as a result of this field experience, she was now questioning how she self-identified (discussed later in this paper). Because there were only 14 faculty members, this student joined an existing student-faculty pair. The students came from universities in the United States and Canada and were all Caucasian, with the exception of one Hispanic and one Asian student. They comprised both geoscience graduates (n = 6) and undergraduates (n = 9), two of whom were non-majors in geoscience. Five were male, and ten were female, with ages ranging from 18 to early 40s. Participants were recruited through the International Association of Geoscience Diversity (IAGD) website and social media, Geological Society of America (GSA) field trip listings, and the Geoscience Education listserv.

Data Generation

As noted previously, qualitative approaches are commonly applied in prior investigations into the learning experiences of students with disabilities. Because human behavior is complex and unpredictable, the lived experiences of human subjects in social and education settings resist numerical and empirical generalization. Specifically, experiences vary among participants and are situation and location specific. In this study, data were generated through multiple qualitative data generation activities including pre- and post-fieldwork focus groups and participant observation and personal communication during the field activity. These methods are entirely appropriate to address the research questions, since these questions focus on understanding specific aspects of the students' experiences of participating in accessible fieldwork.

Focus Groups

The first author conducted focus groups with the student participants before and after the fieldwork. Focus groups are a form of group interview, undertaken in a controlled setting, whereby participants discuss a topic or question put forward by the interviewer. This approach enables rich qualitative data to emerge naturalistically from group interaction and conversation (Cohen et al., 2000; Smithson, 2010), from which insight and meaning can be gained. The pre-fieldwork focus group was conducted the day before the fieldwork and involved all 15 students participating together. The following open-ended questions were put to the participants as topics for discussion:

(1) What are your prior experiences of geology fieldwork?
(2) What are you expecting from this field day?
(3) What does "accessibility' mean to you?
(4) How do you think accessibility will be accommodated during this field day?

These questions facilitated the collection of data relating to participants' knowledge, attitudes, beliefs, and expectations prior to the fieldwork and would serve as a basis for comparison after the fieldwork. Additional follow-up questions were asked in conjunction with these main questions in order to gain further insight or clarification where necessary.

Three post-fieldwork focus groups were held with smaller groups of between two and six students the day after the fieldwork. An additional one-to-one interview was conducted with a hearing-impaired student two days later, while two students did not participate in any post-fieldwork discussion. This change in approach relative to the pre-fieldwork focus group was necessary because the events of the ongoing GSA Annual Meeting meant that participants could not all attend at the same time. The following questions formed the basis for all of the post-fieldwork focus groups:

(1) Tell me about your experiences on the field trip. What happened yesterday?
(2) Having participated in an accessible field trip, have your thoughts about accessibility changed? If so, how?
(3) Did anything surprise you, or did you surprise yourself in any way? Tell me about this.
(4) How could the design of the field trip be improved?
(5) Do you feel that you could now have an impact on broadening participation in geoscience and geoscience fieldwork?
(6) What does the community need to do to improve access to geoscience and geoscience fieldwork?

These questions prompted participants to reflect on and discuss the fieldwork in terms of both their individual experiences and the potential for broader impact (e.g., at institutional level and/or community level). The focus groups lasted up to one hour and were audio-recorded and transcribed verbatim by the first author.

Participant Observation

Participants were also observed in situ over the duration of the field workshop, i.e., at all locations visited, in order to generate the thick description necessary to describe and interpret the behaviors and activities taking place in the field (Creswell, 2003). Observations focused on specific aspects such as social and interpersonal interactions, engagement with learning activities, and personal or physical barriers to engagement. The observations reported in this paper were carried out by the first and second authors while accompanying the participants in the field, i.e., they acted as participant-observers (Robson, 2011). Data were collected in the form of written field notes and photographs and were both descriptive (e.g., physical setting, sequence of activity, and participant interactions) and reflective (e.g., questions to self to consider). All notes were recorded manually and later transcribed into electronic format for analysis.

Data Analysis

The approach to data analysis is similar to that reported in Feig et al. (2019). The analysis seeks to gain insight and understanding into the lived experiences of learners with disabilities participating in geoscience fieldwork through identifying processes, activities, and meanings (see also Magnus and Tøssebro, 2014). Transcripts from the observations and focus groups were imported into NVivo 12, where content was analyzed to identify key emergent themes (Hsieh and Shannon, 2005; Robson, 2011). All coding and analysis were undertaken by the first author. All data contained in the transcripts were first subjected to open coding, whereby key words or phrases that appeared to capture participants' perceptions or critical aspects of their experience were assigned preliminary codes representing initial categories of information (Robson, 2011). Following detailed re-reading of the transcripts, a total of 73 codes were assigned in the first pass of coding. After a period of approximately three months, a second pass of coding was undertaken to check for consistency, and these codes were then combined and refined to establish key emergent themes (e.g., Gibson, 2012), which formed the basis for interpreting the findings. The six dominant themes emerging from the content analysis, together with a frequency analysis, are summarized in Table 3.

While it is common practice to involve multiple researchers in the coding processes, it is also acceptable for coding to be undertaken independently (Saldana, 2009) providing that the trustworthiness and credibility of the analysis can be demonstrated (Krefting, 1991; Saldana, 2009). In this case, the validity and reliability of the data were addressed by triangulating recorded observations in the field with other participant-researchers (specifically the second author), triangulating multiple data sources (e.g., interview and observation data from the first and second authors) to ensure a coherent justification for themes, excerpting data by including substantial verbatim narrative from transcripts and member-checking with study participants (e.g., checking for accuracy of understanding by summarizing or re-stating information during interviews) (Lincoln and Guba, 1985; Creswell, 2003). Peer debriefing, specifically working with impartial peers to examine key aspects of the methodology and findings during the process of compiling and editing this manuscript, acts as a further check on validity (Robson, 2011). These practices are well established in the century-long tradition of qualitative inquiry.

RESULTS AND DISCUSSION

The findings reported here focus on providing an "illustrative flavor" (Creswell, 2003) that can be used to illuminate the phenomenon of accessible and inclusive fieldwork. Throughout the following sections, we present insights into the lived experiences of the student participants illustrated through snapshot discussions and observations, and from these insights, we generate evidence-informed recommendations to help guide the design and delivery of accessible geoscience fieldwork. Findings and discussion are structured by key research questions. All students are referred to by pseudonyms; the pseudonyms Krista and Tim are consistent with pseudonyms applied in Hendricks et al. (2017). Our discussion below describes three basic recommendations: (1) provide multisensory (i.e., beyond visual) engagements, with flexible delivery of content and resources; (2) provide multiple means of (physical) access to sites and features; and (3) set an appropriate pace and timing of events.

What Are the Aspects of Fieldwork Design that Contribute to an Inclusive and Accessible Field Experience for Learners with Disabilities?

Multisensory Engagement

The specific aspects of the pedagogic design considered valuable and important by the student participants varied depending on the nature of their disability. With its emphasis on observation, geoscience traditionally privileges

TABLE 3. KEY THEMES AND ASSOCIATED CODES EMERGING FROM CONTENT ANALYSIS

Theme	Number of unique codes	Number of statements coded	Example codes
Factors influencing the diversity of learner experience	9	68	Mobility issues and/or physical limitations; unseen disability; age; hearing impairment
Factors influencing engagement with learning process	16	99	Anxiety, worries or concerns; motivation; prior experience; assumptions
Outcomes and impacts arising from accessible field experience	9	61	Self-perception and identity; understanding needs of others; new and memorable experiences
Outcomes and impacts beyond accessible field experience	6	49	Advocacy; ambition; employment and/or career aspirations; institutional support
Factors in the pedagogic design of accessible fieldwork	24	182	Multiple means of access; multisensory engagement; flexibility; accommodations and/or adaptations; pace and timing
Social factors	9	96	Community and social inclusion; shared experience; collaboration; field buddy; social interactions

the sense of sight (Pestrong, 2000), and this can create obvious barriers for students with visual disabilities. It can also present opportunities to explore and engage with multisensory aspects of field geology. Prior to the field workshop, Nicole, a graduate student with low vision who relies on a cane to move around, described how she uses multisensory engagement to construct an understanding of the world around her:

> ... field geology tends to be very, very focused on the visual, right? But for me as a blind person my experience is very much more multisensory and integrated in that my visual perception.... so, people think that's it's just oh, I'll touch something and have that tactile thing—but really it's a full, integrated experience for me, where visuals are kind of like, not important.

During the fieldwork, resources were designed using the guidelines of Universal Design for Learning (UDL), a framework for providing a flexible learning environment to accommodate the strengths and abilities of all students (Rose and Meyer, 2002). Specifically, we aimed to facilitate multisensory engagement to make the supplemental field resources available to all participants. For example, the field guide was provided in text and audio formats, and geologic maps were recreated tactilely by representing the main regional geological units with different textures, i.e., varying grades of sandpaper or patterns marked out in "puff-paint." This enabled the students with visual disabilities to study the field guide information while traveling between stops and to use the geologic maps to gain a sense of the spatial layout of the field area and the location of field stops relative to each other. This demonstrated that the instructors valued and expected an inclusive community of learning where all students were actively engaged and expected to participate, and provided diverse representation of the resources that enabled other participants to experience different methods for learning the geoscience content (see Hendricks et al., 2017).

Other opportunities for multisensory engagement emerged directly from the various field locations (Fig. 1; Table 1). At the Cypress Lookout (Stop 2), the increase in elevation afforded spectacular views, but also resulted in a noticeable decrease in air temperature (a tactile experience with the tropospheric temperature profile), and the opportunity to feel intrusive rocks with larger crystals. At Garibaldi Provincial Park (Stop 4), the flowing of Rubble Creek created a unique soundscape, in addition to offering a diversity of rock types with differing physical characteristics that could be explored in multiple ways, e.g., visually and tactilely. In terms of tactile engagement with geology, however, the Stawamus Chief (Stop 5) outcrop was unsurpassed. Here, fine-grained basic dikes cutting through the coarse-grained granite provided evidence for the relative timings of igneous events, while glacial striations enabled the direction of subsequent glacier movement to be deduced (Fig. 2). These features could be observed directly or sensed indirectly, e.g., through feeling the depth and shape of the grooves and changes in rock texture, meaning that all participants were able to make interpretations about large-scale processes based upon their interaction with the outcrop. Indeed, several participants who did not have visual disabilities closed their eyes while feeling the striations and glacial polish, in order to experience these features via different senses. Finally the proximity of the outcrop to the parking lot allowed all participants access to the geology regardless of mobility. For Greta, a geophysics graduate with a mobility impairment, the ability to engage multiple senses contrasted with her experiences of interacting with geology in a lab, where learning typically involved relying on vision:

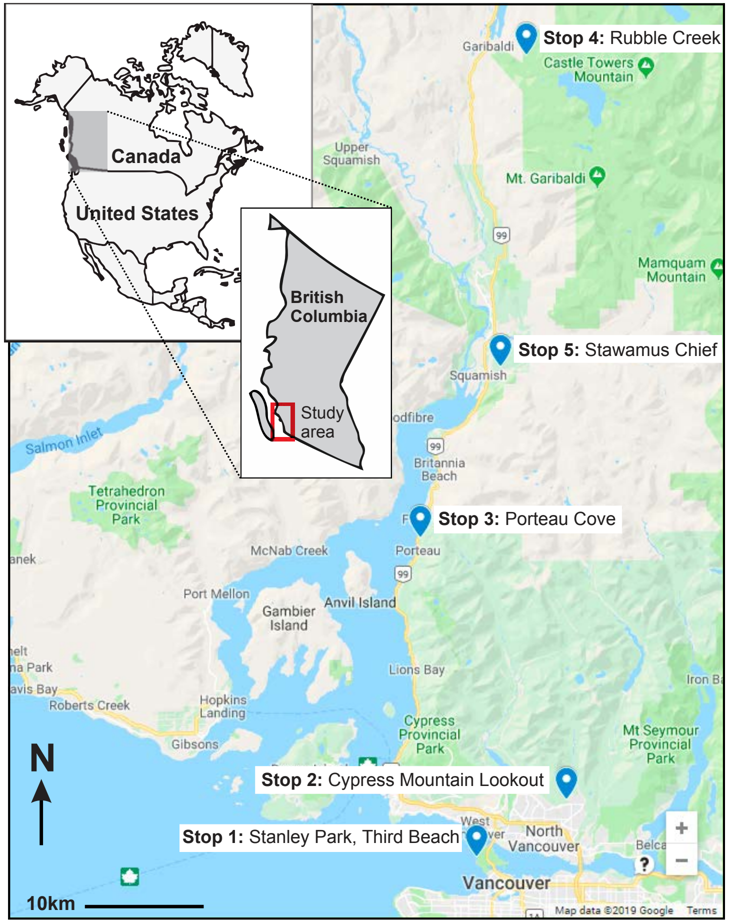

Figure 1. Locations visited along Highway 99 during the accessible field workshop (Google Maps, 2018). Inset shows the general location of the field area.

> Greta: ... at The Chief in particular, where they emphasized the tactile feeling of the striation —I thought that was very neat. And it's also very different to how I'd normally approach geology.

Interviewer: What was different about it?

Greta: "I've never actually bothered to feel the striations, figure out how deep they are—which was also relevant when they were discussing, you know, how were these formed? Was it a glacial flow with lots of sediment, or was it a glacier-on-glacier gouging? The deepness of the striations was a lot to do with that."

Using different senses to engage with geologic phenomena therefore prompted Greta to consider their formation and relevance from an entirely different perspective.

Krista, a college student who is legally blind and uses a service dog (see also Hendricks et al., 2017), took the opportunity to get "hands-on" with natural features that she had previously only read about in books, i.e., to put into context abstract knowledge learned in the classroom. Upon hearing that a dike was exposed in the granite nearby, she immediately let go of her service dog and begin scrambling uphill over large boulders, closely followed by her faculty partner. As she moved her hand across the dike boundaries, feeling the changes in texture between the dike and the wall rock, a group of people gathered around her to talk about the geological significance, but also to share her experience and obvious excitement. Krista recounted her excitement at this experience during the post-fieldwork focus group (note that she used the term "lava" to describe the solidified magma forming the dike): "I liked the lava. That excited me. I mean, it wasn't like hot lava, it was like, cooled down. But I was just like 'I'm touching lava…I am touching lava'! That was very exciting for me"; while other participants, such as Amanda (a mature student with learning difficulties and cognitive disabilities[1]), reflected on the personal impact of sharing that experience: "… what excited me about it was just—just helping [Krista] get up that hill to look at that dike!" Not only is this peer-peer interaction and sharing of experiences a characteristic of learning communities (see following section for further discussion), the associated enhancement of knowledge and expertise in a situated context reflects the creation of a community of practice and promotes sense of identity as a geoscientist (Lave and Wenger, 1991; Wenger, 1998).

Multisensory engagement is clearly important for students with sensory disabilities, but the impact on other types of impairment can be significant for different reasons. For students with cognitive disabilities or learning difficulties, being required to apply more than one sense at a time can lead to cognitive overload and difficulty engaging with the primary learning objective. Oliver, a graduate student with an autistic spectrum condition, described the difficulties that he typically encounters during fieldwork:

…oftentimes when I'm in the field, I get really—you know, it's certainly a full sensory experience. And one of the things that I find being autistic is that … is I can see things, or I can hear things, but I can't process those two pieces of sensory information simultaneously.

[1]These are discrete phenomena, despite the vernacular process of lumping them together. For example, dyslexia is a cognitive impairment, while anxiety brought on by unfamiliar settings presents a learning difficulty.

Figure 2. Participants using touch to deduce direction of motion from glacial striations at Stawamus Chief. Photo credit: The International Association for Geoscience Diversity.

In the case of Amanda, who has both learning difficulties and cognitive disabilities, using multiple senses is necessary to construct understanding but needs to be carefully balanced:

I find some difficulty with fieldwork, mostly because of an auditory working memory disorder that I have that if I don't visually see what [the instructor is] talking about, I don't encode it. So that's a very big problem I have with fieldwork. 'Cause if they're gonna lecture and talk, and you have a working memory disorder or something that doesn't stick, and I have to visually see it—and because I'm dyslexic too, it's even more of a problem trying to learn from just voice. So I've got to see it, I've got to touch it, I've got to feel it. …I've got to do all of it.

In both Oliver and Amanda's case having an unstructured multisensory experience is important, but this may mean applying different senses in isolation rather than simultaneously in order to successfully integrate information at field locations. For learners with auditory disabilities, this can present additional challenges, since they are often entirely excluded from the community of learning, the peer interaction, and the faculty engagement (Hendricks et al., 2017).

Multiple Means of Access

Although fieldwork impacts all students physically, socially, and emotionally (e.g., Stokes and Boyle, 2009), geoscience students with disabilities can experience fieldwork very differently from those who do not disclose a disability.

While typically able to engage all senses, those with limited mobility are often excluded from activities that require participation at field sites that are inaccessible due to rugged terrain. Of the seven student participants declaring a mobility impairment, only two were immediately recognizable as such—one (Cathy) using a wheelchair, and the other (David) a walking stick. For the other five, having non-apparent disabilities had previously caused issues while undertaking fieldwork, particularly in terms of peer and/or faculty attitudes and expectations. These prior experiences had left Jess, a graduate student with an orthopedic impairment, frustrated by fieldwork:

> Jess: It's really difficult if you have a physical disability that you can't see. I'm trying to get this through to [faculty], and you don't seem to understand! And it makes it really difficult because they just don't seem to…
>
> Nicole: When it doesn't look like there's anything wrong with you?
>
> Jess: Yeah. They're like, you're fine, you know—you're not in a wheelchair, so you must be able to walk. And it's like, no!

Ensuring multiple means of access was therefore critical to making the fieldwork inclusive for all students regardless of limitations to mobility. At all locations, learners were able to decide for themselves how best to access outcrops and geological features. As Greta explained, learners became empowered to "choose their own path" and way of experiencing (within the context of a specific, guided learning activity), and in doing so were able to contribute different perspectives to the resulting discussion:

> So when we showed up at the beach, it was like, you can take the ramp, take the stairs, or you can stay up high. You know, you can go see the outcrop, you can go see the sand, you can stand by the water—and people, you know, they split up, they did their own thing, they explored the way that they would—and then, again, re-convening and sharing all of their experiences with each other at the end. That I think made it more accessible, because you picked your path, but there were so many options and your experience and observations were just as valuable as everyone else's.

Pace and Timing

Greta then offered some additional illuminating insight into her experiences:

> I think going the whole day and being able to do everything that everyone else was doing was … I mean, not a surprise 'cause I expected it from this course, but it was unusual that I was able to get the same out of it as all my peers. I wasn't limited in any way; I was able to do all the same things that anyone else was doing.

This is a critical point: consideration of pace and timing, as well as access, ensures that all learners have the opportunity to fully immerse themselves in their learning and make a valuable contribution to shared tasks irrespective of the nature their impairment. Ensuring that field locations can be accessed by all participants may mean reducing the physical rigor involved in an activity, but this does not mean that academic rigor is compromised (e.g., Cooke et al., 1997). For students with cognitive disabilities or those with learning difficulties, an inquiry-based approach that allows sufficient time for exploration and facilitates engagement with learning in the way that suits them best, and at their own pace, is key. At most locations, participants were given a period of time, typically up to half an hour, to explore the location in a way that suited their interests and their abilities, i.e., they were not all expected to explore everything. While carrying out this initial exploration, participants were asked to consider the following prompt: "With your partner(s), use all of your senses and record the things you notice about this site. What do you observe?" before starting to address more site-specific questions.

Based on the key themes emerging from these findings, we recommend that multisensory engagement with flexible delivery of content and resources, multiple means of access, and appropriate pace and timing are prioritized in the design of inclusive fieldwork. Other emergent design principles are discussed in the following sections.

How Does Accessible Fieldwork Design Promote the Development of Learning Communities?

Encouraging and supporting social interaction were key aspects of the field workshop design, but it was less clear prior to the fieldwork how this could support the development of an inclusive learning community. In fact, this manifested itself in multiple ways.

Collaborative Learning

Collaboration between learners and instructors is characteristic of learning communities (e.g., Skop, 2008; Walsh et al., 2014), and the pairing of students with a faculty member meant that this specific social interaction was instigated right from the outset. The bus journey to the first location provided the ideal opportunity for student-faculty pairs to begin to get to know each other, establishing the basis for collaboration during the learning tasks and initiating cooperative relationships, which meant that:

> … everyone had at least one person who was really looking out for them, and that's—that takes an enormous amount of stress off as far as you know you have someone if you have a question, or need help with something—you know you have someone there to talk with. (Nicole).

The shared learning tasks created an incentive for people to work together, and as the day progressed, social interaction was observed to become progressively more fluid; people spent time working with their buddy, but also merged into larger groups to share observations and broaden their interaction, thus facilitating the sharing of knowledge and ideas and broadening out the "social connectedness" from student-faculty to peer-peer. In terms of social learning, these processes reflect students being both guided in their tasks by more experienced practitioners (Vygotsky, 1978) and actively participating in authentic learning experiences with their peers in a novice community of practice (Wenger, 1998; Streule and Craig, 2016).

Social Inclusion

For some learners, the sense of community comes from feeling included both socially and academically (Stokes and Boyle, 2009). Twice during the pre-fieldwork focus group and twice during the post-fieldwork focus group, Amanda alluded to the fact that she felt alone in her studies—isolated by her impairments and her age—and effectively excluded from learning geoscience in general, not just in the field. Interacting and learning with a diverse group of people instilled in her a sense of belonging and a feeling of optimism about her potential future as a geoscientist:

> ... I've felt kind of alone and isolated because of my learning challenges and my age. And just yesterday was like "I don't feel alone!" I'm like, maybe there is a possibility that I can get a job with this school choice, and that really inspired me. It was like, look at all these different people, and we all have different challenges, but we're learning, we're striving to be part of, you know, being a geoscience person.

This sense of belonging, of not being an "outsider," was articulated by four of the student participants and is key to the development of inclusive learning communities (Zhao and Kuh, 2004). Krista stressed the importance of being connected with people who "share the common bond of a disability and having to figure things out," in addition to being part of a community of geoscientists, while participating in accessible fieldwork helped Oliver to "...[feel] more as a partner and an individual in this fieldtrip than in past fieldtrips I've been on where I've felt like I was, sort of, the 'odd' person in the group." Further extending this theme, Greta contrasted the feelings of exclusion that she felt as an undergraduate at her "very white, conservative, wealthy university" with her experience of accessible fieldwork: "I made my friends, but never felt like I was 'in the group,' and for this trip I felt like I was in the group."

Sharing Goals and Experiences

Themes that emerged previously around pacing and timing are also relevant to inclusive learning communities, specifically the sharing of goals and experiences. Comments about being "left behind" or "the last guy back at the bus" emerged on five occasions during participants' recounting of their previous field experiences, as exemplified by Keith, a mature student with a mobility impairment:

> I've been on some fieldtrips where some people that had some kind of a disability, or due to body weight, they were left behind, and kind of looked down on by the rest of the group. Whereas this, we were able to keep everybody together, we were all able to share, you know, the scenery and the geological process, all together.

This shared experience and keeping people together physically extended beyond the learning tasks, to incorporate the traveling between locations. This was particularly profound for Cathy, who as a wheelchair user, found being all together in a vehicle, and all traveling in the same direction, instilled a sense of equality and everybody being "on the same level":

> Like, there were definitely pros to having everybody go off and do certain things that they could achieve physically or developmentally, and then come back and talk about it—but there's also a huge pro to like, all being together and looking at the same thing, and moving forward together—whether that is physically or in your knowledge moving forward.

These findings indicate that accessible fieldwork can successfully promote the development of an inclusive learning community by providing an environment in which students with disabilities feel valued for their contribution, are empowered to be active learners (Walsh et al., 2014), and where they can work collaboratively with instructors to make the learning experience positive and successful for everyone (Sugerman, 2001). We interpret that the commitment to generating and sharing new knowledge through engagement with shared learning tasks, combined with flexibility of approach and high levels of interaction, instills a sense of community that appears to have been seldom, if ever, experienced by these student participants.

How Does Participating in Accessible Fieldwork Promote Self-Advocacy among Learners with Disabilities?

In the context of this study, self-advocacy for the student participants was about being able to make decisions for themselves and being willing to speak out for both themselves and others.

Identifying Needs

Prior to the field workshop, students were asked about their specific needs; so they had the opportunity to self-advocate at this stage. This was helpful in establishing the accommodations that needed to be put in place before the fieldwork began, but the identification of additional needs during the fieldwork relied on the students making these known. Although all students were encouraged to continue self-advocating both for themselves, and for others, during the fieldwork, varying levels of willingness to self-advocate were observed (see also Test et al., 2005). Krista and Nicole, both with visual disabilities, were very open and willing to express what they needed. While Krista's needs were more practical, i.e., needing guidance moving around a location (see Hendricks et al., 2017), Nicole's self-advocacy focused around ways of gaining information and knowledge about a location:

> I was working with [faculty member] a lot, and I sort of explained to her I have …kind of a three-part process where you're perceiving, and appreciating, and expressing something. And as long as you can find a way to do that, right, we can have that meaningful interaction. And she really caught onto it and was able to perceive visual things and really appreciate that, and express it and explain to me in a way that made sense, and was very cool …and accessible for me.

This is a very clear example of students with similar types of disabilities self-advocating for very different needs, and demonstrates that there is no "one size fits all" approach when it comes to making accommodations for specific types of disability.

Other students were less proactive about identifying their needs (Hendricks et al., 2017) or chose not to self-advocate at all. At times during the day Amanda appeared to disengage from the group by moving away to stand by herself. She later disclosed that she had been experiencing anxiety but chose not to make anybody aware of this at the time. So, although some students are naturally very willing to self-advocate, self-advocacy appears to be an iterative process that cannot be generalized across all fieldwork. Indeed some, like Cathy, indicated they would simply prefer to be asked what their needs are up front, rather than be proactive in making them known:

> I think the asking is a huge deal too. 'Cause even sometimes there are people who assume you need more than what you actually need, and don't ask, and just DO! Or just assume that you're going to need a lift to get into any van—'cause I don't—or assume that I need a push .... but I don't! So just like, asking what people need is a huge deal. Instead of assuming they'll tell you, or assuming you know.

However, other comments made by Cathy implied that, rather than promoting self-advocacy, the accessible fieldwork design had simply removed the need to self-advocate at all:

> … this was a big deal to me because I didn't have to fight for anything. I didn't have to go to anybody and say 'I need these things, and you need to provide them,' because I hate doing that. I hate like, having to tell people that you may need to slow down on your trip for me ....

Self-Perception and Identity

A further factor affecting whether or not a student self-advocates is his or her own self-perception as having a disability. This was made explicit by Tim, a graduate student with a severe hearing impairment (see also Hendricks et al., 2017), who admitted to not always disclosing his condition:

> … many people that have a disability, they don't identify themselves. I know, I have seen lots of people wearing hearing aids and nodding like they understand—I do that too, I do that too—but, they don't understand, I know that. They will have to come out and identify themselves that they have this problem. Now, once they identified it, then you can accommodate them depending on what form of communications they can understand.

By choosing not to self-advocate, Tim therefore risks being unable to interact with his peers and to fully participate in learning communities. The most intriguing case of self-perception, however, emerged from Felicity, an undergraduate student who did not initially identify as having a disability and exhibited no visible indications during the fieldwork that she was experiencing any physical discomfort. It was only during the post-fieldwork discussion that she admitted having incurred a serious spinal injury as a child; this injury made coping with the physical exertion of fieldwork difficult, to the extent that she would often be bed-bound for a period of time afterward. When reminded that she had self-identified as not having a disability Felicity replied:

> Well, I guess I've had it for so long, I've never … I mean, when I see some things as disability in my mind, I actually define disability differently, I guess. I was thinking more, um, visually impaired, hearing impaired, wheelchair bound—I didn't consider my back injury….

Students with disabilities, particularly where these are non-apparent, may seek to be seen in the same way as other students and hence reject the "disabled" identity (Magnus and Tøssebro, 2014). In Felicity's case, however, it seems that participating in accessible fieldwork was a transformative experience, prompting her to reevaluate her self-perception and ultimately to reassess her goals:

> Yeah, this has really changed my outlook. Like, I was thinking I wanted to maybe do some type of research, but now I'm thinking I wanna do advocacy. This has really changed my whole outlook on being a geoscientist, for sure … so…. it was a great experience.

The key point to emerge from this is that, although students with disabilities are typically aware of their own needs, not all feel comfortable or willing to proactively self-advocate for these (see also Hall et al., 2004; Test et al., 2005). Indeed, the physical, cognitive, and social complexity of learning in a field setting can prove detrimental to a student's self-advocacy. Hannah, a geoscience major with a visual disability, recounted an occasion when her desire not to draw attention to her limited vision while undertaking fieldwork resulted in her falling and suffering a serious injury:

> I'm legally blind, but I still have a lot of vision, so my professors forget that, and on my fieldtrip last year, I slipped on rocks and broke both wrists. 'Cause they were like, 'Oh you can follow us, we're creating a path ….'

In this case, it seems a combination of reluctance to self-advocate and a desire to achieve normalcy by not identifying herself as "different" (Madriaga et al., 2011) created a situation that could have been averted, had Hannah felt confident in disclosing her impairment and about receiving an appropriate level of help and support from her peers and instructors. Issues around self-advocacy may be further complicated—as in Felicity's case—by the fact that some students may not even identify as having a disability (see Gibson, 2012, and references therein), and therefore perceive no reason to self-advocate. This means that, not only do field instructors need to proactively identify students' potential needs during the fieldwork planning stage, but they also need to be reactive in identifying, and responding to, additional needs as they become apparent during fieldwork. For students with apparent, typically physical impairments, this can be relatively straightforward. The difficulties arise with non-apparent disabilities, or with students who feel unwilling or unable to disclose their needs (Hall et al., 2004; Magnus and Tøssebro, 2014). Ultimately, institutions and faculty have a responsibility to empower students with disabilities to advocate for their needs, rather than expecting them to "fit in" with existing practice (Vickerman and Blundell, 2010). Most importantly, they should provide opportunities for students with disabilities to practice their self-advocacy skills (Roberts et al., 2016) by creating an open and supportive community of learning where concerns can be voiced freely, without fear of bias and stereotype.

IMPLICATIONS FOR FIELDWORK DESIGN

Findings from the data analysis yield important implications for the design of accessible fieldwork. These implications are not just relevant to undergraduate study, they also apply to a range of formal and non-formal educational contexts such as postgraduate fieldwork, field training for industry professionals, and field excursions aimed at amateur interest groups or the wider population.

Pedagogic Design

The key pedagogic design principles emerging from this study, and associated recommendations for future accessible and inclusive fieldwork design, are summarized in Table 4. These principles imply that there is nothing inherently "characteristic" about the pedagogy of accessible fieldwork—from the student's perspective, the design and delivery principles that make fieldwork "accessible" simply come down to good practice. Indeed, it was encouraging to hear participants such as David, a graduate student with a mobility disability, compare their learning experience to a "typical" field course:

> We did an accessible field trip where we looked at geological features, and put them in context of their, you know—how they were formed, why they're important and related questions, and we talked about the geologic timescale. So it was a classic field trip in terms of a geological fieldtrip. But what made it nice was the pace, the consideration for other peoples' limitations, the patience, the teamwork—that made it very comforting and easy to do, and not so intimidating, you know? Sometimes these things can be intimidating, especially when folks are gung-ho and they run up the mountain, and it may seem that you're just stuck there sitting back saying "what just happened?" You know, no one talked to you, where the hell is everybody? That didn't happen, and it didn't even come close to that. So that's what made it unique. But the other stuff was classic geology.

David's comments reinforce the previously discussed finding that pace and timing are critical to the design of accessible and inclusive fieldwork,

TABLE 4. DESIGN PRINCIPLES EMERGING FROM STUDY DATA

Design principle	How the design principle was achieved in this study	Recommendations for future fieldwork design
Multiple means of access	Options for accessing the geology meant that participants selected the method they felt comfortable with and that suited them best (e.g., participants could access Third Beach by steps or ramp or have their field buddy bring samples to them).	Identify locations that offer multiple options for accessing the geology for students with mobility or sensory impairments.
Multisensory engagement	Learning materials were made available in different formats (e.g., written text, audio files, tactile resources, etc.). Learning activities required participants to engage all senses when making observations (e.g., use touch to determine direction of glacier movement).	Make learning materials available in formats that are accessible to different senses (e.g., tactile maps). Build multisensory components into field activities.
Sufficient time at each location	Participants had sufficient time to fully engage with the learning activities at all locations regardless of their impairment (e.g., it was not necessary for students with autism to have to make observations while listening to instruction).	Ensure that the time available for the learning activity and pacing of delivery is sufficient. Spend longer amounts of time at fewer sites. Walking pace should not result in participants being "left behind."
Collaborative learning activities to promote the development of learning communities	Learning activities were designed to encourage collaboration and interaction between students and faculty. Participants were free to interact with whomever they chose, and everyone was brought back together to discuss their learning as a group.	Encourage interaction between students and their peers, and with faculty, during all fieldwork tasks, including downtime.
Focus on academic as opposed to physical rigor	Students were able to complete a full day in the field and achieve the same learning as their peers.	Design activities and choose locations to accommodate different levels of physical ability; designate "scouts" or "fetchers" where necessary.
Promoting self-advocacy	Participants were given the opportunity to make their individual needs known prior to the fieldwork and encouraged throughout the day to speak out if they or another participant needed help.	Invite students to make their needs known prior to and during field activity. Engage with institutional disability services to identify further sources of support.

and have the potential to affect the experience of *all* students, regardless of their abilities. Key to this is the notion that compromising on physical rigor need not come at the expense of academic rigor. On the contrary, allowing sufficient time for learners to fully immerse themselves in an area and interact with their peers and instructors means that everyone has the opportunity to contribute to the knowledge gained from shared tasks. Likewise, building in opportunities for more multisensory engagement can encourage students to incorporate a different perspective into their exploration of geologic processes and products. While we typically think of geology as privileging those with a stronger sense of sight, we do, in fact, rely on other senses more than we might realize (e.g., Pestrong, 2000). For example, we determine the sense of movement on fault planes by feeling the surface of slickensides, we differentiate the grain size of sedimentary rock by chewing a small amount, use taste to identify halite, or differentiate between shale and slate by tapping them on a hard, flat surface. Geology is already multisensory; multisensory experiences need to be integrated better into our teaching and learning. This multisensory characteristic also extends to the use of Universal Design for Learning (Rose and Meyer, 2002) ensuring multiple means of representation, i.e., providing key information in a range of formats (i.e., printed text, electronic text, audio, raised-relief maps, etc.) so that students are able to select the method that suits them best, without having to identify themselves as needing specific support.

Of course, achieving inclusivity is as much about supporting social as well as academic processes. We recommend that fieldwork is informed by theories of social learning (e.g., Vygotsky, 1978; Lave and Wenger, 1991) and meets the basic characteristics for a learning community, e.g., active and experiential learning that supports social interaction and collaboration between groups of learners and their instructors (Wilson and Ryder, 1996; Cross, 1998; Zhao and Kuh, 2004; Skop, 2008; Walsh et al., 2014). This is especially important for students with disabilities who may perceive themselves to be excluded from the social interactions that promote the development of working, as well as learning, communities (Lave and Wenger, 1991; Streule and Craig, 2016). Ultimately, designing curricula to be accessible and inclusive is not about "watering down" the content but about enhancing opportunities for *all* learners (Feig et al., 2019).

Perceptions of Disability

If the design of accessible and inclusive fieldwork reflects the good practice that should characterize *all* fieldwork, the geoscience community needs to challenge and potentially change how disability is perceived and understood. This means, first of all, recognizing the whole spectrum of ability that exists and the range of ways in which "accessibility" and "inclusion" can be interpreted. As implied in the following reflection from David, even students with disabilities may not recognize the full range of potential access and inclusion in fieldwork:

> I came into it thinking, very selfishly, they're all going to be physically disabled, so you're gonna make it physically accessible for me—because that's the world I live in, right? That's my main limitation. I didn't think about cognitive limitations, I didn't think about visual impairments—I didn't think about any of that. I thought 'oh, this is for physically disabled people.' And then I get there, and people have much more diverse limitations than I had ever considered.

If a student with a disability perceives "disability" in a way that does not consciously consider the full range of ability when thinking about accessibility, then faculty are not likely to either (Feig et al., 2019). Developing an awareness and understanding of the issues associated with different types of disability, and how these can be accommodated in field situations, is vital to constructing safe learning environments. Just because one student, or most students, can do something, it does not mean that *all* can. Likewise, *thinking* that we know what students can or cannot do does not mean that we know for certain. This needs to be coupled with a willingness to proactively ask students about their needs rather than making assumptions about what they need or their willingness to ask for these, and also creating a setting where students can develop and practice their self-advocacy skills. Some of the experiences recounted by the study participants point not to a lack of consideration per se, but rather to a lack of awareness about how the actions of instructors and other students are perceived by students with disabilities. As a student with a visual disability, Nicole naturally is very positive about fieldwork and finds that her abilities are often unexpected by instructors and peers:

> I get a lot out of the surprise that a lot of professors and other students experience. They don't expect me to be able to do those sorts of things [hiking and climbing], and then you get out there, and you know, I can do better than some others.

This willingness to challenge the perceptions of others is characteristic of individuals with disabilities who are also strong self-advocates (Test et al., 2005).

All fieldwork participants, instructors, and students need to consider their own perceptions, expectations, and opinions about what students with disabilities can achieve and work toward creating an atmosphere where diversity is valued, all levels of ability are considered, and all contributions are treated with equal importance. As expressed by Oliver, having students with disabilities advocate for accessible fieldwork and actively involving them in the fieldwork design process would make a significant contribution toward ensuring that these requirements are met:

> I can bring back some insights to my department in terms of best practices for running field experiences in general. 'Cause ultimately the adaptations that we make—that are made on this fieldtrip—ultimately could help everyone to some degree.

While instructors may be experts in the academic content of their fieldwork, learners with disabilities are experts about their abilities (Sugerman, 2001), so it seems entirely logical—and crucial—to include them in the design process.

Finally, if students with disabilities are to be motivated and inspired to progress through the geoscience academic pipeline and into employment in the geoscience professions, the perceptions, attitudes, and stereotypes held by professional practitioners also need to be challenged. A recent study has shown that field careers are perceived by professional geoscientists to be among the least viable for people with disabilities, with the extent of viability varying according to disability type (Atchison and Libarkin, 2016). Overcoming these perceptual barriers relies not only on professionals overcoming their own biases and assumptions, e.g., by encountering first-hand the abilities and successes of geoscientists with disabilities, but on learners with disabilities being willing and able to extend their self-advocacy beyond undergraduate instruction, and into the realm of professional training. This in turn requires a better understanding of current and future workforce needs, particularly in relation to skills, while professional organizations need to be open to providing inclusive training opportunities and to engaging geoscientists with disabilities in discussions around making professional geoscience careers accessible to all (Atchison and Libarkin, 2016).

CONCLUSIONS

To date, little attention has been paid to the lived experience of students with disabilities participating in fieldwork. Our findings indicate that the design features that most contribute to making fieldwork accessible and inclusive to students with disabilities, i.e., multisensory engagement, pace, flexibility of access and delivery, and a focus on shared tasks, are also those characteristic of good field practice in general. As such, accessible and inclusive fieldwork design has the potential to benefit the entire learning community, i.e., those students with *and* without a disability or impairment, and the design principles emerging from this study can apply to a range of field-education contexts beyond just undergraduate instruction. These design principles further support the social processes that drive the creation of inclusive learning communities and communities of practice, and help promote self-advocacy by facilitating open and honest communication between learners and instructors. Designing fieldwork to be accessible to and inclusive of all learners from the outset, rather than relying on reactive accommodations, should therefore become standard practice for geoscience faculty and other practitioners involved in the design of field-based activities. A logical next step for this research is to extend the investigation to consider residential fieldwork.

Disability does not exist as a binary, present or absent condition—it is a spectrum on which everyone resides. If, after this discussion, the rationale for making fieldwork accessible to and inclusive of *all* students is still in doubt, then perhaps these last words from Amanda will convince:

> I think anybody that gets into geoscience, regardless of their age or limitations, should have the opportunity to be able to learn and not be judged.

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