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A multiple case study of inclusive learning communities enabling active participation in geoscience field courses for students with physical disabilities

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ABSTRACT

This article presents a multiple case study exploring the emergence of inclusive learning communities within geoscience field courses designed to enable the active participation of students with disabilities. The purpose is to reflect on the outcomes of three distinct projects and consider what lessons can be drawn from them to help promote and inform the development of inclusive teaching and learning. Drawing from established research on learning communities, a set of core practices are applied as an analytical framework to review student and staff experiences across a range of inclusive field experiences. This cross-case comparison provides critical insights into the instructional strategies for the inclusion of students with disabilities in geoscience field courses. Specifically, this work demonstrates the importance of establishing inclusive learning communities through meaningful site selection, fostering social inclusion, and using technology to mediate access and facilitate collaboration in field-based teaching and learning.

Introduction

The purpose of this multiple case study is to explore how inclusive learning communities can be established within field courses involving students with physical disabilities. Fundamentally, field trips provide a social environment through which learning communities organically emerge and develop within the geosciences. When alternate assignments are used in place of field site access, students with disabilities are typically excluded from the valuable social interactions during field studies. Therefore, as a motivation for this work, we argue that purposefully designed, accessible field activities promote social inclusion and collaboration, which will ultimately strengthen the entire learning community by integrating the diverse perspectives of all students.

Within this article, we apply Fink and Hummel's (2015) five core practices of learning communities as an analytical framework to undertake a multiple case study comparison of a series of inclusive field trips. These trips were supported through three distinct projects that set out to develop and evaluate accessible and inclusive approaches to fieldwork. By comparing and contrasting the instructional strategies adopted in each trip using the theoretical lens of the five core practices, we discuss strategies for replicating the development of inclusive learning communities in geoscience field courses.

Background

Importance of field studies

Geologic field study is considered an essential component of a well-rounded understanding in geology and Earth sciences (e.g., Elkins & Elkins, 2007; Maskall & Stokes, 2007; Riggs, Lieder, & Balliet, 2009). Like many field-intensive science disciplines, the geosciences require students to spend time transferring knowledge from the classroom into practical application through personal observation and interpretation in the natural environment. The process of learning

through experience is considered a key element of knowledge development (Kolb, 1984). Drawing from a wealth of social learning literature, Streule and Craig (2016) explained the educational benefits of field trips as opportunities to develop students' sense of identity as geoscientists, their sense of belonging to a community of practice, and their capacity to apply their knowledge and become independent learners. Practical experiences provide a unique opportunity for students to apply their knowledge while creating collaborative relationships that closely resemble the professional working environment by "emphasizing the necessity of co-working amongst fellow geoscientists" (Streule & Craig, 2016, p. 102). Garrison and Endsley (2005) added that the factors of physical activity, synergy, and group work in the outdoor setting set the stage for strong team-building and peer-mentoring skills as well as overall group trust. This aligns to the concept of embodiment (Nairn, 1999), the transformation in identity students undergo on their way from being students to being geoscience practitioners.

Accessible and inclusive field studies

Although a fundamental aspect of geoscience teaching and learning, field studies can often exclude students who are unable to participate due to physical, sensory, or developmental disabilities. As a result, students with disabilities may not develop a practitioner-level identity due to the lack of accessible opportunities to participate in all aspects of a program. The use of alternative assignments designed to accommodate students with disabilities perpetuates a deficit assumption by segregating and excluding students with disabilities from actively participating in fieldwork (Carabajal, Marshall, & Atchison, 2017; Hall, Healey, & Harrison, 2002). Field courses that are designed to be inclusive focus on academic objectives that align to the strengths and abilities of all students, and will ensure an inclusive and diverse talent pool (American Geosciences Institute, 2015; Geological Society of America, 2010; Geological Society of London, 2017).

Field-based instruction often employs a more socially oriented approach to learning than in traditional, instructor-centered classroom settings. These approaches are grounded in constructivist approaches to education, which are founded on Vygotsky's (1978) social development theory. In this theory, social interaction plays a fundamental role in cognitive development through the interaction with people of a higher ability (referred to generically as the "more knowledgeable other") and expands the range of competencies from what individuals can do, with the support of others, to enable them to complete those actions independently (referred to as the "zone of proximal development"). Streule and Craig (2016) proposed that social interaction and the learning experience in geoscience fieldwork are inseparable, and each significantly impacts the other. This integrated learning environment is ideal for implementing collaborative, constructive knowledge building found in learning communities.

Inclusion through communities of learning

Field-based learning is often considered a high-impact practice (Kuh, 2008) due to the deliberate engagement and cognitive dissonance created through the sharing of diverse perspectives, understandings, and experiences. To make field experiences more inclusive, the focus needs to be on social collaboration and community development, and can be incorporated into a range of academic settings, from single-day field trips (i.e., Skop, 2009) to longer-term initiatives (Matthews, Smith, & MacGregor, 2012). A learning community is defined as "an intentionally developed community that exists to promote and maximize the individual and shared learning of its members" (Jessup-Anger, 2015, p. 17).

Aligned to Vygotsky's (1978) social development theory, Wenger (1999) suggested that learning as a result of active social interaction and practice is a key component of social learning theory, with direct implications on the idea of community-focused learning. To be socially inclusive means to value the involvement and contributions of all members of a community. Tinto (2000) described an inclusive learning community as emerging from shared social and intellectual experiences that promote cognitive development through a mutual appreciation and responsibility to consider the diverse perspectives of others. One of the most important aspects of collaborative learning is the ability to build a sense of community and belonging (Tinto, 2000) while enabling diversity of thought and perspectives.

This sense of community has been shown to be especially effective in creating positive learning environments that include the strengths of traditionally marginalized students (Fink & Hummel, 2015; Finley & McNair, 2013). Introduced in the context of inclusion across campus-level programs and instructional settings, Fink and Hummel (2015) synthesized scholarship and practices designed to engage underserved student populations (e.g., students of color, students with disabilities, first-generation students, and transfer students) to participate fully in the educational environment. This synthesis leads

Table 1. A summary of the inclusive field trip case studies.

	Case	Course/trial	Context	Students	Data Sources
Project 1	1	Mammoth Cave National Park (Kentucky, U.S.)	Geology: three-day residential field trip	Six students with mobility disabilities; nongeoscience majors	Pretrip individual interviews; during and posttrip focus group interviews; individual student reflections
Project 2	2.1	Ancient Mountains (Perthshire, U.K.)	Geology: one-week residential field course (run three times)	One student with mobile disability per course in a group of five or six students. Part of a field course with ∼30 students	Observation notes; post-trip interviews
	2.2	Environmental change: The record in the rocks (Durham, U.K.)	Geology: one-week residential field course	A group of eight students with disabilities supported by an instructor and demonstrator; part of a field course with ∼30 students	Observation notes; post-trip email questionnaire
	2.3	Hydrology and meteorology in the field (Yorkshire, U.K.)	Environmental science: three-and-a-half-day residential field course	One student with disabilities supported by an instructor and note taker in a group of six to eight students; part of a field course with ∼34 students	Observation notes; post-trip email questionnaire
	2.4	Vegetation and soils in the field (Shropshire, UK)	Environmental science: three-and-a-half-day residential field course	One student with disabilities supported by an instructor and note taker in a group of six to eight students; part of a field course with ∼34 students	Observation notes; post-trip email questionnaire
Project 3	3.1	Mixed-ability grouping (Northern Arizona, U.S.)	Geology: one-week residential field trip	Twelve undergraduates, six with physical disabilities, working in mixed-ability group configurations	Individual student reflections, posttrip full group interview
	3.2	Mixed-ability grouping (Western Ireland)	Geology: one-week residential field trip	Eleven undergraduates, six with physical disabilities, working in two mixed-ability groups of four and one group of three	Focus group interviews, written survey responses; student reports

to the emergence of core practices, or common strengths, of inclusive learning communities.

Problem statement and contribution

The underrepresentation of students with disabilities within the geosciences is, in part, due to their traditional exclusion from opportunities to learn and work in the field. This is perhaps a reflection of the lack of familiarity of inclusive instructional practices that perpetuates a systemic disadvantage for students, which is increasingly unacceptable within the discipline. Although the geoscience education literature has established the benefits and challenges of field-based instruction, and the broader education literature has identified the affordances of social interaction and community to inform and motivate learners, there are relatively few practical examples of inclusive learning communities involving students with disabilities in fieldwork.

This article demonstrates how an inclusive approach enabling equitable participation in field-based learning benefits everyone. The outcomes of this multiple case study present the voice of inclusive education, which offers insights and recommendations, and encourage faculty to engage and work with students with disabilities and to use these collaborative opportunities to critically reflect on and improve their teaching practice.

Methodology

This multiple case study draws together data collected from students and faculty involved in seven inclusive field courses across three projects undertaken over a 10-year period. Fink and Hummel's (2015) five core practices of inclusive learning communities are applied as an analytical framework. Data gathered across the three projects include observations, questionnaires, reflections, interviews, and focus groups (see Table 1 for details). The analytical framework and case study descriptions are introduced in the subsections below.

Analytical framework

Based on a synthesis of scholarship and practice concerning learning communities (Lenning et al., 2013; Smith, MacGregor, Matthews, & Gabelnick, 2004) and support for underserved student populations (Chávez, 2007; Harper & Quaye, 2008; Jehangir, 2009), Fink and Hummel (2015) proposed the following generalized framework of five core practices of inclusive learning communities:

1. using population-specific theory and research to inform practice;
2. fostering students' bonds to each other and sense of belonging to the institution;

3. engaging students as active learners in the campus community;
4. creating positive message of achievement and change; and
5. advocating on behalf of the student constituency toward systematic improvement throughout the institution.

These five core practices were applied as themes in a thematic analysis of the qualitative data gathered from each of the three projects. The authors involved in each project analyzed their data sources independently (in line with research ethics and informed consent) and then discussed their initial coding to ensure the consistency between analysis procedures and for cross-case validation. Subsequent coding iterations helped clarify examples and explore counter examples between each of the three projects.

Case study descriptions

The first project, presented here as Case 1, developed a single accessible field course at Mammoth Cave National Park as a real-world comparison to evaluate the use of a simulated cave environment (Atchison, 2011). The second project developed and deployed assistive technology to enable nearby remote participation of students with mobile disabilities in four distinct field courses from geology and environmental science, presented here as Cases 2.1 to 2.4. The third project, presented as Cases 3.1 and 3.2, included two field trials as part of a cross-institutional research project to investigate the role of collaborative teams and communication technology for inclusive fieldwork practices. Outcomes from the first two projects, conducted independently by authors Atchison and Collins, respectively, informed the third project, which involved collaboration between all three authors. See Table 1 for a summary of context, participants, and data sources analyzed for each case.

In this multiple case study, the field course context varies from Fink and Hummel's (2015) campus context, in that the third project was run independently of the participating students' universities. Therefore, in Project 3 we consider the students' sense of belonging to the geoscience discipline, rather than to their university institution, as in Projects 1 and 2. Across the seven cases the term *instructor* refers to a field tutor (U.K.) or lecturer (U.K. and U.S.), and the term *demonstrator* refers to the instructional support team (e.g., graduate students and teaching assistants).

Project 1: Physically accessible field course

The field experience in Project 1 (Case 1) was designed to focus on content delivery and physical accessibility in the field (Atchison, 2011) as a way of evaluating the same field site reconstructed in virtual reality. In the end, the direct, in-field experience catalyzed a new focus on inclusive geoscience education for underrepresented students with disabilities. Six students with mobility disabilities were selected to participate in the study and subsequently enrolled in a three-week introduction to cave geology course, followed by a three-day field trip to Mammoth Cave National Park. The group included three male and three female students, with four undergraduates and two graduates. All were wheelchair users (five fully powered and one manual chair). None of the students was a geology major, or even a science major. To develop their understanding of geology, the classroom portion consisted of three, three-hour class sessions, which focused on the basic aspects of cave and karst geology. Because students expressed higher than normal levels of anxiety about going to a place they had long assumed was inaccessible, building a community of trust through transparency, advocacy, and mutual respect was placed as a high priority. Trust was established through clearly defined project goals, information about how the experience would be shared with the broader geoscience community, and reciprocal transparency of expectations and concerns between the students and the project team. Although the students were learning a new subject area, the staff were also learning from the students, who were the experts on their abilities and accommodation requirements.

At the time of the field trip, Mammoth Cave National Park did not offer a publicly accessible tour route. With the assistance of park officials, three primary areas of the cave system were identified as accessible for the field course. Two geology graduate students assisted on the field trip, collaborating with the six students as more knowledgeable others. At each location, students were required to make observations and reflect on the overall experience. While inside the cave, students were divided into two groups and given instruments and instruction to collect measurements of the cave passages (Figure 1). Once back at the research center, students worked collaboratively within their groups to construct a map of the site based on their data (Figure 2).
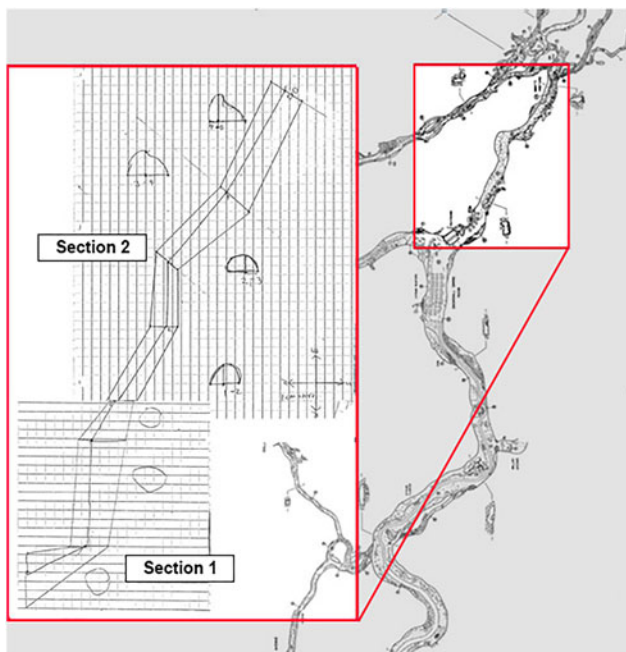
Project 2: Technology-enabled accessible field courses

The *enabling remote activity (ERA)* project (Collins, Davies, & Gaved, 2016; Collins, Gaved, & Lea, 2010;

Figure 1. Photos from Project 1, Case 1, illustrating how students worked collaboratively to (a) measure and (b) describe cave passages. Photo credits: The International Association for Geoscience Diversity.

Figure 2. Student-developed cave map superimposing the Cleaveland Avenue Tour Trail map (Baker, 1996). Section 1, on the bottom of the map, was constructed by Group 1, and Section 2, on the top of the map, was constructed by Group 2 (Atchison, 2011).

Gaved, McCann, & Valentine, 2006) consisted of four separate cases of geoscience field courses, and are presented here as Project 2. This project, based at The Open University in the United Kingdom, has developed the use of mobile and network technologies for undergraduate distance-learning students to enable nearby students to participate remotely in fieldwork. The aim of Project 2 was to provide opportunities for students with mobility impairments to participate fully in field courses. The four courses included two geology field courses (Cases 2.1 and 2.2), and two environmental science field courses (Cases 2.3 and 2.4).

These field courses involved more than 180 students in total, 12 of whom had mobility disabilities.

In each field course, the students completed a series of daily activities and wrote up a field report afterward, which were assessed. Project 2 presents a technological approach to access and inclusion, and uses a battery-powered WiFi network to connect students and instructors at inaccessible field sites with remote students and instructors stationed nearby. Data were shared between on-site and remote locations in the form of photos, live video streaming, and VoIP phone calls or two-way radios. Alongside changes in technology across the four cases, the toolkit was adapted to meet the needs and preferences of specific students and instructors. The main variations were the number of instructors and support workers, their level of subject knowledge and teaching experience, their location, and their pedagogical approach.

Case 2.1 includes data from three instances of a biannual geology field course. In the first course, a field geologist accessed the field site and used the toolkit to communicate with a remote student. Although familiar with the subject, the field geologist had not previously taught the field course and the sites were new to them. In the other two field courses (two years later), an instructor was allocated to support a student directly, and a field geologist accessed the site and used the toolkit to communicate with the student. This time, the field geologist had prior experience of teaching the field course and was familiar with the sites. In each of these three courses, the field geologist was a demonstrator who enabled the student to remotely access the field site from a more accessible location nearby. The approach taken was for the field geologist to be directed by the student, so that the student would actively engage with the field area. Therefore, the teaching and field-site experience

Figure 3. Photos from Project 2, Case 2.2, illustrating (a) students using the on-location computer workstation set up at the field site and (b) a facilitator using a helmet-worn camera to transmit photos and videos from the field site. Photo credits: T. Collins & ERA Project, Open University, UK.

of the field geologist was a significant benefit as they could actively engage the remote student and instructor in a form of Socratic dialog to help ensure the student achieved the learning objectives.

In Case 2.2, the instructor accessed the site directly and led a group of eight remote students through it, while the demonstrator supported the remote students (Figure 3). Although the instructor took more of a guiding role, introducing the students to the site, dialogue was used to ask the students questions and engage them in critical thinking and reflection. Finally, Cases 2.3 and 2.4 involved a student with physical disabilities enrolled in two separate environmental science courses. The instructor on both courses had extensive knowledge of the field site and varied role to match the student's needs at each site. During these two field courses, the student worked with a group of six other students and was supported by a note taker. At the less accessible field sites, the instructor either worked with the group using the ERA toolkit to actively involve the remote student (as in Case 2.2) or worked directly with the remote student (as in Case 2.1) while the note taker or another student operated the communication tools at the field site.

## Project 3: Collaborative technology-supported field experiences

Project 3 was a multi-institutional project, formally titled "Engaging Students in Inclusive Field Experiences via Onsite and Remote Partnerships." This project (Cases 3.1 and 3.2) used findings and key outcomes from Projects 1 and 2 to develop methods of inclusive, on-site field learning with collaborative teams and technology integration (Haddock et al., 2017; Marshall, 2018; Thatcher et al., 2017). The population comprised

12 undergraduate geoscience students in Year 1, with 11 returning in Year 2. Six students identified as having a physical disability that limited their participation in traditional field courses. The same group of students participated in two week-long field experiences in consecutive years: Northern Arizona in Year 1 (Case 3.1) and Western Ireland in Year 2 (Case 3.2). For both field trips, each student was provided with a digital tablet for field data collection and communication with their teammates (see Haddock et al., 2017).

Case 3.1 featured a week-long field study of the regional geology in Northern Arizona. Learning activities were generally short exercises similar to those common in weekend or one-day undergraduate field trips in stratigraphy and volcanology. Students worked in pairs each day—one student who identified as having a disability, and one student who did not. Activities in fully accessible locations were completed with partners staying together throughout the exercise, whereas activities in locations with less accessible areas sometimes required partners to split up to collect their data (Figure 4). Notes, measurements, photos, and videos were collected and shared when the pairs regrouped. When separated, communication and data exchanges between partners were limited to the use of two-way radios and brief use of video streaming at locations where the cellular service was stronger.

The second week-long field trip (Case 3.2) took place in Western Ireland the following year and was conducted with more advanced learning activities typical of upper-level field courses in soft-sediment deformation, structural geology, and glacial geomorphology. This required developing the collection and synthesis of complex geologic data into finished products, such as maps and reports. This field trip
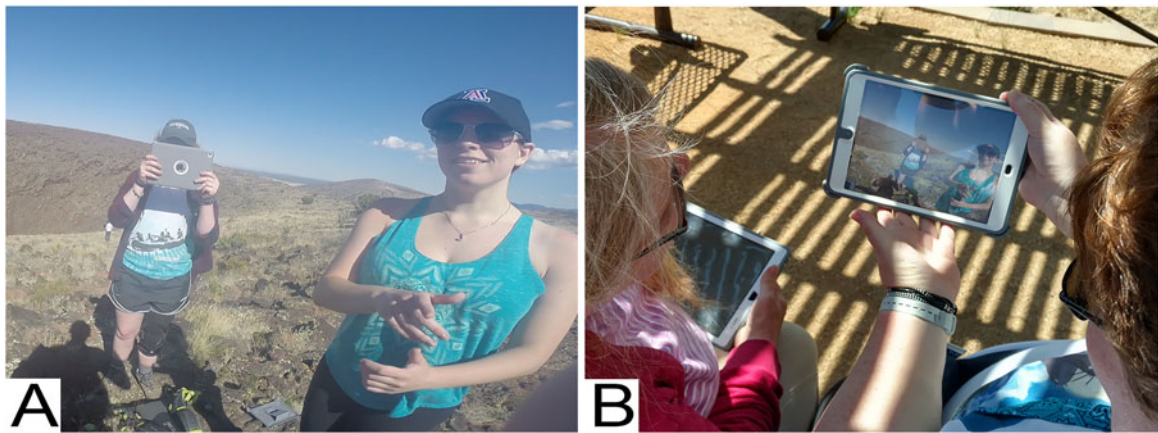
Figure 4. Photos from Project 3, Case 3.1, illustrating the use of the digital tablets to (a) live stream video from students at the top of a volcanic crater and (b) students at an accessible base station. Photo credits: The International Association for Geoscience Diversity.

Figure 5. Photos from Project 3, Case 3.2, illustrating the collaborative approach to a field mapping exercise with students collecting and sharing data from (a) outcrops in less accessible terrain and (b) accessible outcrops along a gravel road. Photo credits: The International Association for Geoscience Diversity.

expanded the use of technology from Case 3.1 to include the WiFi network adapted from Project 2 (introduced in the previous subsection). For the first activity, students were free to choose their own collaborative groups but were essentially working independently. For the rest of the week, students were assigned to teams of four—two students who identified as disabled and two who did not. The multiday structural geology mapping activity required the collection of data along an accessible gravel road as well as inaccessible locations due to the terrain, so pairs from each team relied on each other to collect geologic data from separate locations (Figure 5). In the evenings, data were merged to create a collaborative map and report of the entire field site (Figure 6). Combined with deteriorating weather conditions, the third activity was a half-day exercise that used real-time video communication and photo sharing to enable synchronous collaboration between

teammates at an inaccessible outcrop and their partners working from vehicles parked nearby (see Thatcher et al., 2017).

Results

The purpose of comparing these cases is to reflect on the outcomes of these projects and to consider what lessons can be drawn from them in order to inform and promote the development of inclusive field-based teaching and learning strategies. Here, we return to Fink and Hummel's (2015) five core practices of inclusive learning communities to review our experiences. In citing excerpts of the qualitative data from students in each of the seven cases, we make a distinction between able-normative students (ANS) and students with disabilities (SWD), and indicate the data source (i.e., questionnaire, reflection, interview, or focus group).

Figure 6. Student teams divided data collection during Case 3.2, as some worked from less accessible locations along the lake and more accessible locations along the road. Data collected across the entire field area were merged in the evenings to build a collaborative structural map of the site. Photo credits: The International Association for Geoscience Diversity.

Using population-specific theory and research to inform practice

The development of the inclusive field trips was informed by research in disability studies that champions inclusive education motivated by the social model of disability in the United Kingdom and the minority group model in the United States (Connor, Gabel, Gallagher, & Morton, 2008). The student-first perspective underpinned the approach taken to make necessary adjustments to the field course activities to align to an individual's abilities.

In particular, Project 2 built on work published through the United Kingdom's Geography Discipline Network on issues affecting students with disabilities undertaking fieldwork and related activities (Healey, Jenkins, Leach, & Roberts, 2001) and strategies for fieldwork involving students with mobility impairments (Gardiner & Anwar, 2001). These included adjusting the objectives and prioritizing accessible field localities to provide an inclusive curriculum—rather than modifying practices or offering alternative experiences, which can perpetuate an exclusive

curriculum—and introducing the use of assistive technology where needed to improve accessibility and facilitate social inclusion. The role of integrating technology to assist access was commented on positively by several students. For example:

> The ERA technology was superb, without it I would have been a spectator, instead I was a contributor. (Case 2.3, SWD questionnaire)

> My injury will likely be degenerative as my hips have to take way more than they should. I love that I will still be able to basically be there, and be more included as technology improves. (Case 3.1, SWD reflection)

The formation of group structures in each of the three projects were also inspired by social learning theories. In particular, Vygotsky's (1978) social development theory, which introduced the themes of social interaction, the more knowledgeable other, and the zone of proximal development, prompted the use of mixed-ability grouping. In Projects 2 and 3, groups were formed with participants with differing levels of geoscience content knowledge to promote socially constructive learning. Across the cases, students commented on the benefits they gained through engaging with their peers or instructors; for example:

> I helped the [instructional] staff in ensuring that what we were doing was relayed clearly and, in doing so, I repeated some of what was said. As we were learning the scientific names of the vegetation around us I think this helped me, and perhaps others in my group, to commit them to memory. (Case 2.3, ANS questionnaire)

> It was really fortunate that [student] has a background in petrology and I have a background in sedimentology, allowing us to share our knowledge. Experiences like this develop collaboration skills, enhancing the study at hand and future projects. (Case 3.1, SWD reflection)

> This approach … made you focus on each other's strengths and weaknesses, so I think you got to know each other on a deeper level. (Case 3.2, ANS survey)

Fostering students' bonds to each other and sense of belonging

The second core practice from Fink and Hummel (2015) described the importance of social and intellectual bonds between students as well as a sense of belonging to the institution (i.e., the field course, geoscience discipline, and/or their university). Bonding between the students was an important and valued aspect across the cases. In Case 1, the physical engagement and exploratory nature of the experience created strong social bonds between the students, particularly because this was a first-time experience they all were sharing together. Because this trip was designed specifically for wheelchair users, students were able to focus on learning rather than being concerned about issues of access. As one of the students noted,

> [I]t was a place and time where I was accepted as me and the disability was just a part of the package. … I was given, for the first time, the ability to be myself and learn without any stressors pertaining to disability. (Case 1, SWD reflection)

In all cases, the students were organized into small groups, which also included a range of discipline knowledge and experience, creating a social setting in which valuing contributions from all students was especially important, as illustrated in the following excerpts:

> S1: [All] of us had each other's back. … There is so much team building right here, in this environment, and it's out in the nature. … It was great.
>
> S2: Yeah, we build off of each other's strengths.
>
> S1: All of us working together, that's what I love the most, how close we have all gotten; we were all looking out for each other. (Case 1, SWD focus group)

> I felt that [the remote student] was an integral part of the group, I hope he did too. It was very important to all members of the group that he felt included and able to make some very insightful and useful contributions to our discussions. (Case 2.3, ANS questionnaire)

> To work with people as partners or in a group, to have someone actually listen to me is a great experience. … I didn't realize how validating it was until someone actually listened to me. (Case 3.1, SWD reflection)

Fostering a sense of belonging is especially important for members of underserved populations. In Project 3, all students were geoscience undergraduates. Interview data from the students with disabilities indicated that most of them struggled with feelings of exclusion from the discipline at their home institutions (Marshall, 2018). In Project 1, students were not geoscience majors, and some students indicated that this was in part due to the perception of geology programs as inaccessible. In each of the cases within these projects, students began to see themselves as geoscience practitioners through the activities:

> I now view geology as not only very practical but also as a science that can be accessible to students with disabilities. At the beginning of this course I assumed the opposite. (Case 1, SWD reflection)

Throughout this whole experience, I have questioned whether I would have actually pursued geology if I was given the chance to do it and was told I could do the work. … I felt like I was given a real chance to learn the material the way it should have been presented to me the first time. (Case 1, SWD reflection)

Similarly, in Project 2, involving students with disabilities in established field courses enhanced the sense of belonging to the university for all students:

[Y]ou've got to keep up with the others, otherwise they'll think you've got special privileges … part of the thing is to mix with the other students because you're personally part of the university. (Case 2.1, SWD interview)

Attending the residential [field course] gives students the chance to feel like part of a community and I believe that it is important for everyone to be able to experience that. (Case 2.3, ANS questionnaire)

Engaging students as active learners in the wider community

Fink and Hummel (2015) described a learning community as a group in which all students are actively engaged in the learning process. Each project used different approaches to participation, yet each cultivated an environment that enabled all students to actively contribute. Because of the unique focus on inclusion for members of an underrepresented group in the geosciences, there were two specific aspects of active learning: the acquisition of geology knowledge and skills, and the development of inclusive field practices (i.e., the social and academic inclusion of students with disabilities).

Active learning of geology

In Project 1, active learning was encouraged in the selection of an accessible and unique field site where students could directly collect data collaboratively. Students were excited to work in a research capacity"

When in the cave, hypotheses were developed, data was [sic] collected, then the data interpreted and plotted. … I learned more in two days than I could ever learn from a book or in a classroom setting. (Case 1, SWD reflection)

In Projects 2 and 3, student groups were often separated due to physical barriers in the field. For example, in the mapping activity in Case 3.2, only parts of the site were accessible for the students with disabilities, so the student groups were regularly divided, with each pair being responsible for collecting data in their respective field areas. Therefore, to complete the map of the field, each group relied on reciprocation of effort, as observations and data from both groups were needed to make interpretations of the entire field site (see Figures 5 and 6). To do this, students employed technology to collaborate in real time which strengthened the learning experience for all members of the group. In separate interviews, teammates described the active learning that took place during real-time, synchronous video communication and photo sharing from different field locations:

I videotaped [a remote teammate] and [my field partner] having a conversation. … [My field partner] was just trying to describe it in the best way that [they] could. … So I took the [tablet] and I stuck it up as high as I could, right close to where [my partner] was looking. I went all around so that they could see what they were discussing, while they were discussing it. (Case 3.2, ANS focus group)

One thing that worked really great was that they were describing what they were seeing. [The teammates at the outcrop] took a video of what they were describing where you could hear the overlaid voice in the background describing what they were seeing. … You got the gist of it, and you were able to, with your knowledge, ask them to look for certain things and ask them if it looked like this or it looked like this. And then when we got back together … we were able to resynthesize everything together. (Case 3.2, SWD focus group)

The use of technology to enable remote collaboration also created unforeseen setbacks. Social dynamics occasionally interfered with each student's engagement and active learning in some field activities. During Project 3, the able-normative students were often unintentionally described by both faculty and students as data-gatherers, whereas the students with disabilities were most often described as data-interpreters. Some able-normative students felt this dynamic left them with only a physical contribution to field work without significant academic collaboration. One student expressed this frustration and a desire to contribute more than just to "hike and take photos" (Case 3.2, Focus group interview). Conversely, there was an expectation that teammates who were not able to physically access locations in the field would be able to contribute knowledge and data interpretation for those locations. But the students with disabilities occasionally felt their geoscience content knowledge was not sufficient to interpret the data, or that they were limited in what they could contribute due to infrequent communication between pairs during the field day. However, when roles

remained flexible and adaptable to each group and activity, students were more at ease with communication and tasks, and felt a sense of accomplishment and inclusion when individual contributions coalesced into a finished product:

> The division of labor, particularly with app usage and technologies … each member of our team had different areas of expertise, and the way we split up the final mapping project based on what we knew how to do, and our field impressions was really neat to see in action. (Case 3.2, Focus Group Interview)

Active engagement was also prevalent in Project 1, in which students were given a chance to move beyond mere exploration and apply skills obtained during classroom instruction, while also using tools to collect data needed to map a portion of the field site.

> I learned a lot from class lecture, pictures, and reading but seeing the sinkhole, Green River, Mammoth Cave, and mapping the cave gave me a better understanding. The experience was remarkable, something I could never get from a book. (Case 1, SWD reflection)

In this activity, the students self-divided into two groups and were provided with blank data tables, tape measures, compasses, protractors, and electronic distance meters. During the activity, the student groups collected survey measurements and made broad observations of the geomorphology of the cave passages. The following excerpt from one of the student's reflection on the experience illustrates the active learning that was taking place:

> I took a tape measure and one of the other girls held the other end of the tape measure and the other person took down all the measurements that were called out. We also used a compass to judge the direction from one point to the next. The mapping process was cool because we learned how geologists mapped out the caves to [find] the different entrances. (Case 1, SWD reflection)

Although the two groups were working autonomously, when the two sections were merged, they fit perfectly together into one map (see Figure 2).

Active learning in inclusive field practices

For Project 3, in which students were recruited with an understanding that the overall project goal was to study inclusive practices, students took an active role in that research. Each field trip provided a week of activities designed to teach geology field skills and data collection methods to the students. Yet qualitative data suggests that although students valued the opportunity to enhance their geology content knowledge and skills, they were most focused on their role in the development of inclusive practices. When

speaking of their daily priorities in the field, two teams responded: "to develop a method of collaborative fieldwork that could be taught and translated to other schools and/or used in other locations" (Case 3.2, focus group) and "to test different technologies that could improve access and inclusion in the field" (Case 3.2, focus group). Evidence of their success in these endeavors was celebrated in the field and later discussed in interviews:

> [A student working remotely through live video] was pointing out that the rocks were falling off the cliff side due to erosion due to the tides and like wind basically. And as soon as I saw it I was like, "Oh, my god, yeah, he's right!" And it was [the remote teammate] that pointed it out; which is, like the definition of being inclusive because he was included! He was able to really see it. (Case 3.2, ANS focus group)

> I felt by the end of the trip we had it down. Like we were good that last day … even though it was just an hour and it was a brutal location. Even for that little amount of time I think we really had it in the bag. It worked … it was like a model you could deliver to other schools. (Case 3.2, SWD focus group)

Creating a positive message of achievement and change

The positive impact of inclusion across the learning community was a common theme across the three projects. During Project 2, the inclusion of students with disabilities in established field courses gave a strong message that promoted a holistic approach to supporting equitable participation by all students:

> [SWD] being able to participate so fully in the course was one of the highlights of my stay at the field center. (Case 2.3, ANS questionnaire)

> I feel that using the ERA technology opens up many courses to students who might otherwise have problems fully participating in the residential element of the course. (Case 2.4, note taker questionnaire)

Across the cases from each of the three projects, students came together not only to learn a new subject but also to apply that learning while undertaking rigorous fieldwork. The sense of achievement and change this brought within the individual students was clear in the feedback they provided:

> This is my first experience where I did the work. … I will never forget how to map a cave! I loved mapping the cave and had such a feeling of accomplishment when the boys' map fit perfectly to our map. (Case 1, SWD reflection)

> Physically I feel very tired and very sore. … Mentally I am glowing like a supernova. I have more

confidence in my abilities to properly apply what I've learned in Geology to the things I've seen, and to actually have a good discussion with other people about what we are looking at. Positive support and conversation and encouragement are so important to everybody. (Case 3.1, SWD reflection)

For the students with disabilities, these experiences strengthened their motivation to engage in further in the discipline, and through future field studies. Students reflected on their experiences:

Knowing that it is possible to get to field sites as majestic as the Grand Canyon and participate in research initiatives has opened my mind to the potential I have to travel to other field locations. (Case 3.1, SWD reflection)

[J]ust realizing that everyone is here for you … I think this was a really good start to realizing that this is something I can actually do. (Case 3.2, SWD focus group)

These supportive learning communities instilled a sense of change in the broader landscape of education as well, as one student remarked:

Having this trip shows me that attitudes are changing for the better and positive attitude changes in many ways gives me hope for the future [for] persons with disabilities. (Case 1, SWD reflection)

Advocating on behalf of the student constituency toward systematic improvement

All three projects had strong results in terms of advocacy for systemic improvement beyond the scope of the individual projects. In particular, Project 3, which had a one-to-one ratio of students with and without disabilities, created an environment in which students could make meaningful connections between groups who had previously had very different experiences of fieldwork. These students were encouraged to advocate for each other during the field studies, from physical well-being to treating one another equitably (i.e., that everyone was offered an opportunity to be included in all of the social and academic activities). For some, this interaction provided a sobering realization of the many ways in which students with disabilities are excluded from learning experiences are often taken for granted by others. After a particularly physically strenuous field day, one able-normative student remarked:

Getting that perspective that I didn't really have before … where there's no allowance for having a disability and so you're just left with this hollow version of a field experience. … I was like—we need to fix this! … Getting that perspective and getting to

carry that forward into the rest of the trip and the way we act, I thought was a really interesting and valuable part of this. (Case 3.2, ANS focus group)

The mind set of inclusion continued to be applied beyond the field portion of the project. Notably, when a group of students from Project 3 presented a poster about their experiences at a national geoscience meeting (Thatcher et al., 2017), one of the members had to return home before the presentation. The students recognized this barrier to participation and devised a solution by setting up a video call on a tablet in front of the poster, allowing the missing teammate to interact with conference delegates in real time alongside their coauthors.

A number of students and faculty (with and without disabilities) became active in advocating for disability inclusion after participating in these projects. Project 2 was awarded a university teaching award and an innovation award at an international learning conference, which created opportunities to promote inclusion to the broader academic community. After Project 3, several able-normative students recognized the need to improve access and championed efforts for change within their university departments and campuses. One student created a blog to inform and encourage others with similar disabilities undertaking field work in remote locations, and another student pursued and was elected to serve as an accessibility representative on the local city council.

Perhaps the most notable example of how these learning communities promoted advocacy for systemic change is the creation of the nonprofit International Association for Geoscience Diversity (IAGD) by the lead researcher on Project 1. Originally formed as an advisory group in 2008, the IAGD has now grown into an international organization that provides support, research, training, and advocacy for inclusion in academic and professional geoscience settings.

Discussion

Field experiences from three projects have been presented through the lens of five core practices of learning communities (Fink & Hummel, 2015). In drawing comparisons across the seven cases, two pertinent themes emerge that warrant further discussion in the context of developing communities that address the inclusion of students with disabilities—namely, the provision for physical and social access to learning.

Thoughtful selection of physically accessible field sites that allow all students to engage directly in field activities is the most direct way to create an environment in

which learning communities can develop through shared experiences (Project 1). However, many locations of geologic interest may be partially or fully inaccessible for some students. In these instances, technologies can be used either synchronously (i.e., real-time video streaming, photo sharing, and VoIP communication, as in Project 2 and some activities in Project 3) or asynchronously (i.e., data, photos and videos were shared sporadically, as in some activities in Project 3) to mediate remote access to the field site.

The outcomes of this multiple case study indicate that strong learning communities can thrive, even across inaccessible field sites, when access to collaborators and inclusive learning activities are prioritized. All seven cases demonstrate the importance that all students should have a clear understanding of how they will participate. For example, during Case 3.2, when students' expectations of the accessibility of the field site matched the reality, and appropriate tools for alternative means of participation were available (e.g., video streaming and photo and data sharing), students had positive feelings about inclusion. However, when student expectations did not align with the reality in the field and the appropriate tools were not in place to enable meaningful participation, students developed negative impressions of the experience.

Social inclusion is a critical component of a learning community. In each of the three projects, social inclusion was closely linked to academic engagement, as students had opportunities to share thoughts and ideas within their group, thus becoming more actively engaged in the field learning activities. Learning communities rely on the development of a group identity and a cohesive approach to assigned tasks. Seemingly counter to this idea, students must also feel an individual sense of belonging to the community and purpose, and ownership in the learning activities. This is especially important in field courses with limited physical accessibility, in which it is difficult for all students to remain engaged in a learning community when they do not have an active role in the learning process. Although physical inaccessibility can be mitigated by appropriate use of technology, effective mitigation strategies must be coupled with the social inclusion of all students in the field course activities.

One of the activities that prompted the strongest feelings of inclusion was done entirely through remote collaboration (Case 3.2). This was the result of applying the lessons learned through all three cases regarding personal empowerment, academic inclusion, collaborative groupings, and the effective application of technologies. Although this is promising in terms of approaches to inclusive field learning, it is important to caution against unilateral decisions regarding the degree or type of access that is appropriate for all students with disabilities. Across the three cases within Projects 1 and 3, students were emphatic that everyone should be involved in decisions regarding the type and degree of participation that is appropriate for each activity. The application of technology should not be viewed as the solution to inclusion but as a tool to be used to enable participation within a larger framework of an inclusive learning community when safe physical access is not possible. Although technology can provide access to the field, integrating social inclusion is most necessary for enabling collaboration within the entire learning community.

Limitations

Although we would argue that an inclusive mind set encourages and facilitates equitable participation, it is important to point out that the primary focus of the three projects presented in this study was to develop learning communities inclusive of students with mobility disabilities, and we did not necessarily attempt to address accommodations for other disability types. Therefore, further exploration is also needed to expand this work to develop inclusive approaches more widely across the intersection of sensory, cognitive, and developmental abilities.

All three projects cover a range of student participation types and whole group formations. Although the cross-case analysis included the three authors, the data collection protocols were different for each project, thus potentially limiting the generalizability of the outcomes to the broader geoscience community. Additionally, the three cases discussed from Projects 1 and 3 focus on relatively small groups of students (six, 12, and 11, respectively) and included a deliberately higher proportion of students with disabilities than seen in typical field courses. In contrast, Project 2 presented four field courses, each involving more than 30 students, which included students with disabilities either as a single member of a group (as in Cases 2.1, 2.3, and 2.4) or as a distinct group of students with disabilities (as in Case 2.2).

Finally, there are many effective approaches to fostering the development of inclusive learning communities, including the technology-enabled approaches used in Projects 2 and 3. We realize that communication is a necessary aspect of the collaborative nature of field work for students with disabilities, but the use of technology presented here as a way to mediate

access and inclusion in the field introduces further expense and requires some knowledge of mobile and network technologies. Many geoscience departments do not have access to a digital toolkit and the support of technology specialists needed to effectively implement replicate this approach.

Conclusion

We strive for equitable participation in field-based learning through thoughtful field site selection, social inclusion, and remote collaboration. However, many prime field sites are inaccessible across a spectrum of physical ability. In these instances, mitigating barriers include assuring that all instruction and debriefing, including whole-group communication of key observations and interpretations of the field sites, are conducted collectively at a location accessible to all. Additionally, when prime field sites are not accessible for all students, we recommend the integration of technology to mediate accessible participation and communication. All seven cases presented here demonstrate the importance that all students should have a clear understanding of how they will participate.

Purposeful design and integration of inclusive learning communities have the potential to break down the barriers of access to field-based teaching and learning. Through this study, we emphasize that full participation does not require complete physical access to all field activities. What full participation does suggest is that all students should have access to the field and be included in the community of learning through social integration and active collaboration. Doing so will create a stronger, more engaged learning community, in which everyone's perspective is included and valued.

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