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"Nothing about us without us:" The perspectives of autistic geoscientists on inclusive instructional practices in geoscience education

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ABSTRACT

Increasingly more students with disabilities, including autistic or otherwise neurodiverse students, are studying for degrees in STEM field subjects. In recent years, there has been an increased effort from the geoscience education community to make teaching more accessible and inclusive to these students. However, much of the literature on this topic lacks the voice of the individuals these practices aim to serve. This, combined with the medical, deficit-based understanding of autism typically presented in the literature, has resulted in the perpetuation of harmful stereotypes, along with recommendations that may not actually serve as best practice. Here we present a more accurate and holistic explanation of what autism actually is, using our lived experiences as autistic geoscientists. We then outline a comprehensive framework for best supporting autistic and neurodiverse geoscience students, with a focus on field-based learning. This framework includes three pillars: (a) develop effective communication pathways with autistic students, (b) presume competence and include autistic students in the planning of their own accommodations, and (c) employ strategies for expectation management. We also touch on the importance of recognizing the sensory processing aspects of autism spectrum conditions and suggest strategies for minimizing these difficulties in a field environment. By centering autistic voices in the discussion of how to support autistic geoscience students, we hope to change the narrative of inclusion for this diverse, but significant population.

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Introduction

Although increasing attention has been paid in the scientific literature to improving access and inclusion of students and practitioners with disabilities in Science, Technology, Engineering, and Mathematics (STEM) education and careers (e.g. Hartman, 2019), the geosciences have had the lowest participation rates of individuals with disabilities when compared to its STEM peers, (Locke, 2005; NSF 2017). While most efforts toward inclusion of students with disabilities in geosciences have focused on physical (Gilley et al., 2015), sensory (Hendricks et al., 2017), and other non-apparent disabilities (De Paor et al., 2017; John & Khan, 2018; Tucker & Horton, 2019), there has been increasing effort in recent years to help geosciences attract and retain neurodiverse participants - students diagnosed with, for example: ADHD, Autism, dyslexia, dyspraxia, and those with mental health challenges. These include initiatives such as improving field mapping and geoscience education accessibility for students with Autism Spectrum Conditions (ASCs) as reported in Lang and Persico (2019), and Billing and Feldman (2017), and increasing dialog in the literature to recognize challenges and support of mental health in the field (e.g. John & Khan, 2018; Tucker & Horton, 2019).

These efforts are an important step in the right direction of inclusive planning and design across our discipline and along pathways to geoscience careers. However, the dissemination of scholarship regarding support for autistic students within the geoscience education community appears to be lacking the voice of the students and the population that they are trying to serve. Likely due to the omission of autistic voices, these recent papers - to varying degrees - have fallen flat in a key way: they are grounded in harmful stereotypes about autism, and give suggestions for 'supporting' autistic students which have the potential to harm more than help.

At some point in their career, all geoscience faculty members will find themselves teaching autistic students whether or not the students explicitly disclose such diagnoses. Recent studies suggest that as much as 1.9% of the student population of a large public university in the United States could be autistic (White et al., 2011). If we consider this to be representative, a typical introductory geoscience class of 150

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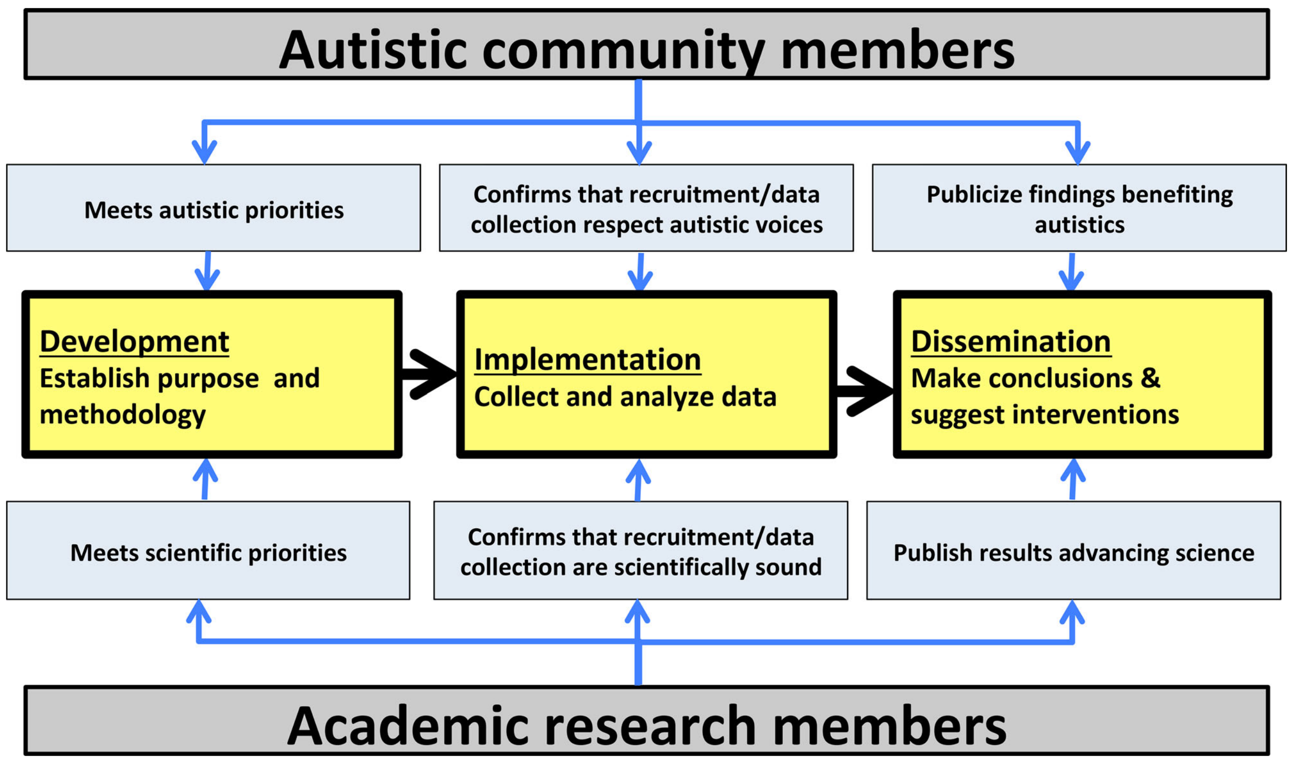


Figure 1. The Community-Based Participatory Research (CBPR) process. Yellow boxes represent the life cycle of a typical research project and blue boxes represent roles and tasks during different phases of the research project (Figure adapted from Nicolaidis et al., 2011).

students would include 2-3 autistic students, and this likely holds true for geoscience majors as well.

As autistic and neurodiverse geoscientists (first three authors), we are excited to see greater attention being paid toward educating the geoscience education community about ways to accommodate our unique needs and improve the accessibility and quality of education for all students. We seek not to criticize the overall work and efforts to improve geoscience educational opportunities for autistic students, but rather to demonstrate how centering the voices of autistic individuals, the population most affected by the content of these recent efforts, would have made these publications both more useful and potentially less harmful to autistic and neurodiverse students.

In addition to the insights from autistic geoscientists, we include the broader perspective from the inclusive geoscience education community (through the expertise of the fourth author) to improve the support and education for autistic geoscience students, both in direct response to recent publications regarding autistic students in the field, and by raising significant points that we feel have been missed. There is a prominent theme within the disability rights movement of "nothing about us without us" (Scotch, 2009), and we urge future contributions to the field of inclusive geoscience education to consider more actively including members of the population they are working with at all phases of the research and dissemination process (e.g. Snow, 2013; Nicolaidis et al., 2011).

Throughout this paper, we provide resources which respect the autistic experience, as well as provide a framework for understanding autism beyond simply a spectrum of communication disorders that makes people behave oddly. There are many resources available which can provide information about autism while also respecting the humanity and dignity of autistic individuals (e.g. the Autistic Self-Advocacy Network and the Academic Autism Spectrum Partnership in Research and Education [AASPIRE]), which can improve the way in which educators and students can work together to support neurodiverse students at all levels.

Best practices for research impacting populations of people with disabilities employ the Community-Based Participatory Research (CBPR) model of inquiry (Nicolaidis et al., 2011; Nicolaidis et al., 2019; Figure 1), and actively include all of the stakeholders, especially those with disabilities, throughout the research process. As part of the CBPR model of inquiry as applied to autism, at least one autistic person who has contributed to the research would normally be offered co-authorship status. CBPR and similar models have been successfully employed in research about medical treatment (e.g. Snow, 2013; Iezzoni & Long-Bellil, 2012) and to better support autitsic individuals, both within the medical field (e.g. Raymaker et al., 2017) and in educational community settings (e.g. Crompton et al., 2019). By following the principles of CBPR, geoscience education researchers can ensure that the individuals most impacted by the outcomes of the study – people with disabilities and those from other commonly underrepresented groups – are given a voice and are deeply involved in every step of the research cycle from design to dissemination (Figure 1; Nicolaidis et al., 2011).

Here, we draw upon our diverse experiences as autistic geoscientists, students, and researchers in accessible geoscience education, to address common issues and solutions for better supporting autistic geoscience students. We include direct responses to published literature and contribute some additional suggestions we feel will improve access, inclusion, and outcomes for neurodiverse students entering the geosciences. The central tenet of the disability rights movement, "Nothing about us without us", is a rallying cry for access and inclusion centered around the needs of individuals with disabilities, and the process of collaboratively making decisions that will ultimately impact them directly. We hope that by adding our perspectives to this conversation, we will provide an improved (though hardly comprehensive) framework for increasing and improving access to geoscience education for autistic students. We also encourage other researchers working in accessibility and education to reach out and include members of the community they are working on behalf of, in all stages of research, from conception to publication.

What is autism really?

A common thread in recent papers discussing ways to support autistic university students, is an incomplete and fundamentally destructive definition of autism, usually citing symptoms such as "obsessive desire for sameness", "repetitive behaviors" and "difficulty or failure to communicate" with neurotypical people. This definition, which focuses entirely on stereotyped observations of autistic individuals, is commonly sourced from the Autism Speaks website which, although the most well-known autism charity, is not considered by most autistic people to be a good source of information about autism (e.g. Sequenzia, n.d.; Ne'eman, 2009; Nicolaidis, 2012). Their information regarding autism is historically grounded in a 'deficit-based medical model' that was first defined by Laing (1971) and is mired in stereotypes and misconceptions, containing information that is unhelpful at best, and dehumanizing at worst. The end result can lead to well-meaning research and inclusion efforts that perpetuate ableism, and are ultimately harmful to the targeted population they hope to support (e.g. Billing & Feldman, 2017).

At its core, autism is an information processing condition that results in different sensory experiences and ways of thinking that depart from the "normal" experience (Autistic Self Advocacy Network, n.d). As a result of these differences, the way autistic individuals perceive and interact with the world is, in many ways, structurally different from neurotypical interaction. A chief way this manifests is in how autistic sensory systems process external stimuli, and the coping mechanisms that are developed to deal with those stimuli. In many circumstances, these coping mechanisms are developed despite great physical and mental cost to the autistic individual, who is constantly consciously assessing many pieces of sensory input across sight, sound, and touch, that most people would not be aware of.

Recent research has demonstrated this heightened, multisensory perception of one's surroundings as Intense World Theory of Autism. This type of extreme information input and processing can lead to some of the stereotypical symptoms of autism, including sensory sensitivity and sensory seeking behaviors, auditory and language processing challenges, repetitive behavior, and intense interests (Markram & Markram, 2010). Imagine being able to hear every conversation around you at the same volume, while simultaneously hearing other background noises at an intensified volume, being able to smell someone's lunch from the other end of the outcrop, feeling the rough texture of the rock you're sat on, the tag in the back of your t-shirt, and being continuously dazzled by sunlight that no one else thinks is especially bright. Now imagine you also have a different understanding of pragmatic language to everyone around you, which takes you longer to decipher. Processing all of that information in real time is exhausting.

Most autistic adults have spent their entire lives developing conscious 'filters' and other coping mechanisms in order to handle the volume of sensory input regularly experienced that is not naturally sortable due in large measure to the structure of the autistic brain. As a result, autistic individuals typically support a much higher baseline cognitive load than their neurotypical peers, which can lead to mental fatigue. Further, these filters are not always immediately able to adapt to new information or new types of input, especially if there are other sources of stress already in the environment. This means that an autistic individual's buffering ability to handle novel situations or sensory input is lower than most, making them more susceptible to overwhelm, distress, and confusion, particularly in unfamiliar situations, such as a field camp. This can present as real-time processing delays, and can lead to meltdowns. Similar to when a beaker is overfilled with water, resulting in water spillage, meltdowns manifest when an autistic's sensory systems intake more external sensory stimuli than it can internally process. This bombardment of sensory input results in a "spillage" of emotions and actions that can manifest in a variety of ways, including but not limited to: screaming, crying, kicking, and/or biting (e.g. National Autistic Society, 2016). Physical "lashing out" can be directed at one's self, rather than surrounding people. Lower buffering ability may also lead to a shutdown, which is the complete inability to process information and can manifest as the temporary inability to verbally communicate, or even physically move as the autistic person's filters get overwhelmed.

There are two schools of thought in terms of how to handle the interaction between autistic individuals and surrounding external stimuli: the medical model of disability, which focuses on the deficits exhibited by the individual, and the social model of disability - the external, or environmental factors which exacerbate those challenges (e.g. Haegele & Hodge, 2016). The medical model suggests that autistic individuals' sensory systems need to be "cured" before the person in question can function or learn effectively. However, following the social model of disability, with appropriate supports, adequate information, and a general understanding of these challenges, it is straightforward to create an environment in which autistic students are able to learn and contribute as effectively as any of their non-autistic peers.

Strategies for supporting autistic geoscience students

Develop effective communication pathways with autistic students

Barriers in social and collaborative interaction between autistic and neurotypical peers is often a result of differences in the way autistic individuals communicate rather than a lack of communicative ability (Crompton et al., 2019). Reducing communication barriers with autistic students is similar to communicating with an international colleague who does not share your language. Take appropriate steps to clarify communication and acknowledge the potential for misunderstandings, rather than reducing the content level. Clarifying communication and misunderstandings can go a long way toward providing a positive and effective learning experience not just for autistic students but for all students in a class. The difference in communication styles between non-Autistic and Autistic individuals is referred to as the Double Empathy Problem (Milton, 2012). More recent work has been completed in this area by the Diversity in Social Intelligence Project at Edinburgh University (Crompton et al., 2019), demonstrating that autistic-to-autistic information sharing is just as effective as neurotypical-to-neurotypical, but that the autistic-neurotypical information sharing pathway breaks down. This communicative discrepancy extends to all forms of communication, including body language. However, difficulty communicating does not mean that content should be made simpler or the student should be spoken down to.

Autistic individuals may have atypical body language which can be misinterpreted as not paying attention, or disinterest. For example, an autistic student may avoid eye contact, or look away entirely while listening to a lecture or discussion. Rather than indicating disinterest, many autistic individuals are better able to understand and process verbal input when they are not looking at the speaker. For many autistic individuals, acting out the appropriate body language to indicate listening in a way that a neurotypical instructor may understand, is exhausting and uncomfortable, taking away mental energy that would otherwise be spent on listening and comprehension of the lecture material. Further, autism is often characterized by repetitive movements that are commonly called ‘stimming’. Not all autistics rock, flap and hum, but when autistics do, it doesn’t necessarily mean distress; an autistic individual may increase stimming as part of their information processing, or simply as an expression of happiness (e.g. Bascom, 2011). While autistic body language may seem foreign, allowing autistics freedom of movement and leaving space for them to move their bodies in ways that may seem counterintuitive, rather than forcing them to sit still or actively suppress their need for stimming behavior, greatly reduces the mental load, and allows the autistic student to focus on learning.

Autistic individuals may not display emotions or respond to certain situations in the socially expected manner. A change in behavior, rather than a specific action, may signal that the student is having a potential problem. For example, many autistics experience shutdowns when overwhelmed. Shutdowns are often described as a complete inability to process information, verbally communicate, or sometimes even physically move. For many autistic people however, this is the final stage of a progressing shutdown. Initially, verbal communication may not appear to have noticeably declined, though the person may have reverted to known phrases and responses that do not accurately represent what they are feeling or thinking. This can be a particular challenge in field-based settings, where the situation is unfamiliar to the student, so developing a plan ahead of time with the student for noticing signs of overwhelm and shutdown, and outlining potential mitigation strategies is essential. For example, a student, may feel increasingly overwhelmed in a crowded environment around an outcrop, and in trying to move away, shut down completely in a potentially dangerous situation (e.g. mid-stream crossing). Learning to recognize non-typical, but common indications of autistic distress can help mitigate such situations before they occur, as can developing contingency plans or locations for a student to ‘take a break’ from an overwhelming situation in a safe manner. To this end, we suggest instructors in collaboration with the autistic student, identify safe and alternative options to employ in the event of shutdowns in the days leading up to field course departure.

Many autistic individuals have challenges with processing verbal communication in real-time. Communication can be improved by using plain language, avoiding sarcasm or idioms, asking one question at a time, being deliberate about the types of questions (yes or no vs. open-ended) posed, and allowing additional time for students to process and formulate a response. Some autistic students may communicate part- or full-time using augmentative and alternative communication (AAC) devices (Zisk & Dalton, 2019). This can take the form of a letter-board for spelling, typing on their phone, or other text- or picture-based communication systems. While these systems can be slower than the natural pace of a verbal conversation, allowing students the time and space to process and respond to questions, and to make observations, demonstrates respect for their efforts to communicate, and improves learning outcomes for the students involved.

Presume competence: Autistic individuals are experts in their autistic existence

We encourage professors and university educators to acknowledge and respect autistic intelligence and expertise, recognizing that autistic university students are young adults going through the same developmental stages as their neurotypical peers. While much of the literature (e.g. Elias & White, 2018; Lang & Persico, 2019) suggests working with the autistic university student’s support team, disability services, and even their family, to develop appropriate supports, it is of paramount importance to remember that autistic individuals are experts in their own lives, and we encourage inclusion of autistic students in all planning phases for their accommodations. It is also important to bear in mind that what works for one autistic person may be detrimental to another - always ask whether an accommodation or modification would be helpful, and be willing to take suggestions, even if such supports are atypical. For example, one of the authors regularly carries a soft blanket to feel, not only as a way to lessen the urge to bite and mutilate their fingers but also as a way to help maintain focus and grounding during intellectually demanding tasks such as writing. In addition, the same author also wears a pressure vest on certain occasions to help with grounding, focus and to greatly lessen the prospect of shutdowns. The pressure vest works by assisting with the regulation of sensory input. Transporting rock samples in a backpack with tightened shoulder-, chest-, and hip-straps can offer similar benefits to the pressure vest on field traverses while the pressure vest can be used in camp when doing evening collaborative activities. While an external support team may have good ideas for improving access and accommodations for an autistic student, and can be included in those conversations, the main driver of such conversations should be the autistic individual as the expert.

Aim to meet with students several times well in advance of any planned trips and ask them about their personal communication needs. In some students, this can, from time to time, include speech being limited or non-existent. Students that experience non-verbal periods will typically have developed other ways of communicating such as through communication cards, a whiteboard, or AAC apps on their phone. Also be aware that some autistics may have a very specific understanding of certain words or phrases, regardless of the context in which they are used. For example, some individuals may greatly struggle to respond to the question, "are you okay?":

> *I understand it to mean, "at this precise moment in time, what is your emotional state?" If a teacher uses "are you okay?" to check understanding of the work, I may think "I'm fairly happy right now, so yes". The satisfied teacher then walks off and I get no help with the work I was struggling with. –Z, Autistic postgraduate*

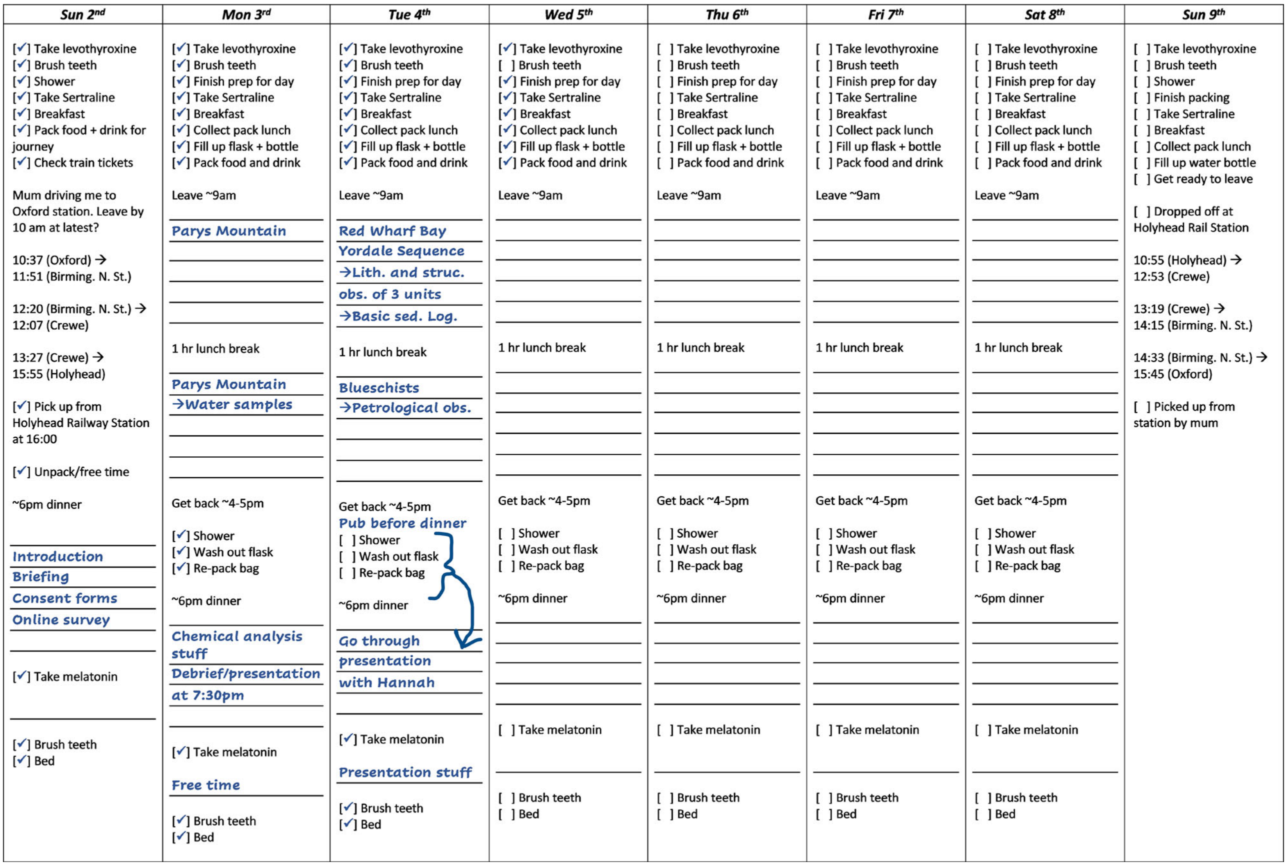
We recommend establishing a predetermined method of "checking in" with an autistic student when in the field. For some students, a set of self-assessment questions (e.g. "have I eaten food recently?" and "what are two things that I think I understand and two things I do not understand about this assignment?") may help to guide their understanding in the field. Further, many autistic students have learned from a young age that being "pulled aside" equates to being reprimanded for a behavior that was likely out of their control. These negative associations certain autistic individuals have with being pulled aside makes this form of "checking in" very anxiety provoking. Establishing a routine for checking in with an autistic student prior to the beginning of a field trip, can help to alleviate these anxieties, and improve communication and learning in the field.

Employ strategies for expectation management

A common misconception is that autistic people have an "obsessive desire for sameness" and an "inability to handle change" (Kanner, 1943; Wing, 1988). While it is true that many Autistic people benefit from the structure of having a constant routine, and may dislike deviating from that routine, it is because changes and novel situations can effectively "clog" the mental filters meant to deal with sensory input, which can greatly reduce the amount of information that can be processed in real-time. This stereotyped view of autism inhibits opportunities for students to participate in new learning experiences. When working with autistic students, it is far more helpful to create "predictability" than "sameness", as predictability helps to establish a framework of expectations for the student to work within. This "expectation management" framework can be applied to scheduling, activities, food, behavior, and assignments, and allows for increased flexibility while reducing stress.

Participating in fieldwork and field trips is a capstone experience of nearly all geoscience educational programs. While students are well-practiced at the situations presented by classroom instruction, leaving this familiar environment for the unpredictability of studying in the field can be a daunting and overwhelming experience. New situations, particularly field-based ones, often include significant new sensory stimuli, as well as new social rules and safety guidelines, many of which may seem arbitrary to students (see Electronic Supplementary Material for more details). Providing curricular context to the tasks and concepts involved in fieldwork or a field trip prior to the trip itself, is particularly helpful in managing expectations in the field. While all students benefit from having field techniques introduced as curricular components in prerequisite courses, rather than for the first time during a large trip, having field techniques reinforced well before departure makes the transition into the field easier for neurodivergent students. Practicing these techniques in a more controlled or lower-stakes setting prior to departure (Lang & Persico, 2019) allows autistic students the opportunity to practice managing the non-educational variables of fieldwork, such as wearing unfamiliar field-appropriate clothing or sun protection, before it is necessary to use the practical academic skills on a larger trip or project, and allows the students to better understand the tasks asked of them in the field.

One of the best ways to support autistic students in the field is to be aware of the types of situations or stimuli that may be challenging. While the exact challenges will vary from individual to individual, providing a framework of expectations prior to a trip can go a long way toward priming students for success in the field. For example, many autistic people are very sensitive to the textures and tastes of food, making it difficult or impossible to "go with the flow" and eat whatever food is provided. Autistic people, in particular, may find that it is much easier to tolerate 'hunger' than it is to tolerate the sensory input of certain foods, which can lead to restricting intake during field trips and camps. Sharing the meal plans ahead of time, and planning flexible "buffet-style" dishes gives students the opportunity to determine how and what kind of food they need bring to supplement the group's food, as well as a sense of what to expect at mealtimes. A similar framework of expectation



Sun 2nd	Mon 3rd	Tue 4th	Wed 5th	Thu 6th	Fri 7th	Sat 8th	Sun 9th
[✓] Take levothyroxine [✓] Brush teeth [✓] Shower [✓] Take Sertraline [✓] Breakfast [✓] Pack food + drink for journey [✓] Check train tickets Mum driving me to Oxford station. Leave by 10 am at latest? 10:37 (Oxford) → 11:51 (Birming. N. St.) 12:20 (Birming. N. St.) → 12:07 (Crewe) 13:27 (Crewe) → 15:55 (Holyhead) [✓] Pick up from Holyhead Railway Station at 16:00 [✓] Unpack/free time ~6pm dinner Introduction Briefing Consent forms Online survey [✓] Take melatonin [✓] Brush teeth [✓] Bed	[✓] Take levothyroxine [✓] Brush teeth [✓] Finish prep for day [✓] Take Sertraline [✓] Breakfast [✓] Collect pack lunch [✓] Fill up flask + bottle [✓] Pack food and drink Leave ~9am Parys Mountain 1 hr lunch break Parys Mountain →Water samples Get back ~4-5pm [✓] Shower [✓] Wash out flask [✓] Re-pack bag ~6pm dinner Chemical analysis stuff Debrief/presentation at 7:30pm [✓] Take melatonin Free time [✓] Brush teeth [✓] Bed	[✓] Take levothyroxine [✓] Brush teeth [✓] Finish prep for day [✓] Take Sertraline [✓] Breakfast [✓] Collect pack lunch [✓] Fill up flask + bottle [✓] Pack food and drink Leave ~9am Red Wharf Bay Yordale Sequence →Lith. and struc. obs. of 3 units →Basic sed. Log. 1 hr lunch break Blueschists →Petrological obs. Get back ~4-5pm Pub before dinner [ ] Shower [ ] Wash out flask [ ] Re-pack bag ~6pm dinner Go through presentation with Hannah [✓] Take melatonin Presentation stuff [✓] Brush teeth [✓] Bed	[✓] Take levothyroxine [ ] Brush teeth [✓] Finish prep for day [✓] Take Sertraline [✓] Breakfast [✓] Collect pack lunch [✓] Fill up flask + bottle [✓] Pack food and drink Leave ~9am 1 hr lunch break Get back ~4-5pm [ ] Shower [ ] Wash out flask [ ] Re-pack bag ~6pm dinner [ ] Take melatonin [ ] Brush teeth [ ] Bed	[ ] Take levothyroxine [ ] Brush teeth [ ] Finish prep for day [ ] Take Sertraline [ ] Breakfast [ ] Collect pack lunch [ ] Fill up flask + bottle [ ] Pack food and drink Leave ~9am 1 hr lunch break Get back ~4-5pm [ ] Shower [ ] Wash out flask [ ] Re-pack bag ~6pm dinner [ ] Take melatonin [ ] Brush teeth [ ] Bed	[ ] Take levothyroxine [ ] Brush teeth [ ] Finish prep for day [ ] Take Sertraline [ ] Breakfast [ ] Collect pack lunch [ ] Fill up flask + bottle [ ] Pack food and drink Leave ~9am 1 hr lunch break Get back ~4-5pm [ ] Shower [ ] Wash out flask [ ] Re-pack bag ~6pm dinner [ ] Take melatonin [ ] Brush teeth [ ] Bed	[ ] Take levothyroxine [ ] Brush teeth [ ] Finish prep for day [ ] Take Sertraline [ ] Breakfast [ ] Collect pack lunch [ ] Fill up flask + bottle [ ] Pack food and drink Leave ~9am 1 hr lunch break Get back ~4-5pm [ ] Shower [ ] Wash out flask [ ] Re-pack bag ~6pm dinner [ ] Take melatonin [ ] Brush teeth [ ] Bed	[ ] Take levothyroxine [ ] Brush teeth [ ] Shower [ ] Finish packing [ ] Take Sertraline [ ] Breakfast [ ] Collect pack lunch [ ] Fill up water bottle [ ] Get ready to leave [ ] Dropped off at Holyhead Rail Station 10:55 (Holyhead) → 12:53 (Crewe) 13:19 (Crewe) → 14:15 (Birming. N. St.) 14:33 (Birming. N. St.) → 15:45 (Oxford) [ ] Picked up from station by mum

Figure 2. An example planner used at base and in the field by an autistic student on a week-long field course. The checklists serve as prompts for daily medication, hygiene and nutrition tasks, and help with executive functioning, whilst the spaces to fill in enable the student to create a visual timetable for the day - including what tasks are expected of them at particular localities. By laminating the planner, it can be used as a dry-wipe board, allowing for flexibility and changes to the schedule.

management can be built around appropriate field gear and clothes. Take the time to discuss the weather of the field location, as well as the types of appropriate clothes, layers, shoes, and protective gear well before the trip and allow ample time for students to acclimate to and practice with any new clothing or gear they may need. Additionally, share information about taking care of bathroom needs and availability in the field prior to the trip (Greene et al., 2019) so that students can prepare and bring appropriate supplies as necessary.

While in the field, autistic individuals may experience considerable visual and/or auditory processing challenges that are not present in the classroom, such as bright sunlight, complex scenery, wind, and unfamiliar noises. This sensory overload can make it difficult for an autistic person to hear or take in information in the field, and in extreme cases, can lead to meltdowns or shutdowns. While these stimuli are unavoidable in the field, breaking up lectures into shorter segments, including additional information in a printed field guide, and, where possible, choosing locations with minimal distractions for group discussions, can help improve learning outcomes. Additionally, having a plan in place for a student to take breaks from the group setting to recover from overstimulation can improve overall comfort and safety in the field. Some students may also benefit from having a "buddy" who they can check in with directly about course content and logistics if they are feeling lost. We draw attention to various potential overstimulation scenarios like we describe in this paragraph, the previous paragraph and possible ways of managing these sensory overstimulations in our Electronic Supplementary Material.

A common "solution" for supporting an autistic student is establishing a daily schedule. Such schedules, when constructed appropriately, provide significant reductions in anxiety, and can support a student's executive functioning. However, as field trips rarely go according to plan, constructing a rigid schedule may cause more harm than good. For example, if a 30-minute field stop expands to a 2-hour stop, a student who has been told "we'll spend 30 minutes here", may have mentally transitioned out of the stop after 30 minutes, expecting to be moving on. They may then be experiencing significant anxiety as the schedule they were told is now messed up. Alternatively, stating "this stop has these three goals, and we expect to be here for somewhere between 30 and 60 minutes, though it could be longer, and we'll see how everyone is doing before we decide to move to our next stop" tells the student what to focus on. In addition, the alternative statement we offer above gives a framework for how scheduling works, and provides information about what the next steps will be, all of which can improve the student's ability to engage with the course content, rather than worry about the schedule. Further, scheduling

Table 1. Sample schedule showing general plan of a typical day in field mapping camp.

7:30 AM - 8:00 AM	Wake up, shower, prepare pack and materials for field work
8:00 AM - 8:30 AM	Breakfast
8:30 AM - 9:00 AM	Morning discussion
9:00 AM - 5:00 PM	**Activity**: Field Mapping - Lunch and snacks will be determined based on pre-set times agreed to immediately following morning discussion. **Location**: Vredefort Dome, North West Province, South Africa **Bathrooms**: There are no bathrooms on field traverse, but are available in camp mornings prior to departure and evenings after arriving back in camp. **Daily Goals**: Find and map the contacts between major lithological units in the map area.
5:00 PM - 6:00 PM	Personal time – suggest showering.
6:00 PM - 7:00 PM	Dinner
7:00 PM - 8:00 PM	Group work, evening discussion
8:00 PM - 10:00PM	Personal time
∼10:00 PM	Suggested bedtime

and discussing mealtimes and strategies, as well as bathroom breaks and other nonacademic aspects of life in the field can reduce unknown variables, and help students focus more on the tasks at hand.

Some autistic students may already have coping strategies in place to try and manage their anxieties surrounding predictability and routine. For example, the dry-wipe planner in Figure 2 provides a daily framework for daily field-based activities but also includes tasks for helping with executive functioning, placing priority reminders on specific hygiene and nutrition needs which may otherwise be forgotten during a major change in routine (e.g. Table 1). Such strategies can be encouraged and introduced as a possible idea to students that don't already have such coping strategies in place. This should be done well in advance of a field trip so that the strategies can be tried and tested beforehand, and always utilized in addition to the other suggestions made in this paper, not instead of them.

To help students better understand and plan for how daily life works on a field trip or field course, we recommend sharing past field trip photos and sample schedules to help manage expectations prior to trips. This can be done by creating a dedicated webpage within the departmental online presence. Photos of people working at the field sites should focus not only on the science aspect of trip (i.e. two people measuring a stratigraphic section) but also provide context for non-science daily life on the field course and include students preparing and eating meals, photos of sleeping quarters, and recreational activities. Linking to hosting services such as Flickr allows for larger numbers of photographs. Further, posting the course syllabi on the website well in advance (>1 month) of the start of major field courses serve as a way for course policies and regulations to be known to students ahead of time. Further, making the document publicly available allows future students to understand what field experiences are like socially and operationally. Including information such as a generalized schedule of activities detailing a typical day in the field also helps illustrate a typical day's events (for an example, see Table 2). This allows the students to observe the setting and get an understanding of the social and environmental structure of the trip, pack appropriate down-time activities and clothing, and better prepare for the daily activities during the trip.

Useful community resources

In addition to employing best practices for universal design in class planning (Silver et al., 1998; Rose & Meyer, 2002), we encourage those currently, or planning to expand their work to focus on issues of access and inclusion in teaching, learning, and research activities across the geosciences and beyond to become familiar with the growing network of resources available.

The Supporting and Advancing Geoscience Education at Two Year Colleges (SAGE 2YC) project resources supported the implementation of "high-impact, evidence-based instructional and co-curricular practices… that will lead to improved STEM learning, broadened participation, and a more robust STEM workforce" (SAGE 2YC., 2019). Similarly, the International Association for Geoscience Diversity (the IAGD), and their formal UK Chapter sponsored by the Geological Society of London, Diversity in the Geosciences (DiG-UK), is a growing network of geoscience students, instructors, and practitioners, with and without disabilities, working to develop communities of resources and instructional best practices to support the entire geoscience community.

Recent geoscience education research is working to advance instructional inclusion and address cultural stereotypes and biases that exacerbate exclusionary practices across the discipline, most notably associated with the rigors of field-focused activities (e.g. Atchison et al., 2019; Atchison & Gilley, 2015; Carabajal et al., 2017; Feig et al., 2019; Gilley et al., 2015; Stokes et al., 2019). The benefits of integrating inclusive pedagogical practices are advancing through research that focuses on the entire student learning community (Atchison et al., 2019; Atchison & Carnahan, 2018). Geoscience education scholars are advocating for universally and inclusively-designed programs to bring out the strengths and abilities of all students.

We also encourage researchers to look at resources provided by autistic-run organizations and neurodiverse individuals, to learn more about autism, the autistic experience, and how they may be able to better support autistic individuals. For example, the Autism Women's Network, the Autistic Self-Advocacy Network, and the Thinking Person's Guide to Autism are all free, online resources which provide significant resources for those aiming to better understand and support autistic individuals. These sites, as well as others, provide large directories of blogs and essays by autistic adults, including published research scholars, which provide further insights into the autistic experience. Recent publications, including the book NeuroTribes by Steve Silberman, (Silberman, 2015) go farther in addressing the history, science, and development of our understanding of Autism and neurodiversity.

Conclusion

As increased attention is paid toward creating more inclusive environments in which to train the next generation of geoscientists, it is paramount to understand and involve those populations in the theoretical and practical efforts to better support these students along their paths toward a geoscience education. Here, we have drawn on our personal experiences as autistic geoscientists and an inclusive geoscience education researcher, to address a gap evident in the academic discourse that surround supporting autistic students in geoscience educational programs: the voice of the autistic individuals themselves. While by no means comprehensive, we provide context for how autism can impact individuals with a focus on geoscience education situations, give tangible examples of challenges faced by autistic students, and suggest strategies for mitigating those challenges that maintain academic rigor while achieving the desired learning outcomes for all students. While autism is often construed as a social interaction disorder, the associated sensory processing difficulties are often the root of challenges faced by autistic students. Working with individuals to establish effective modes of communication and help manage expectations, can go a long way toward improving the academic experience for autistic geoscience students. As more diverse populations of students gain access to a university-level education, it is important to employ a community-based participatory research paradigm to research efforts about those populations. We encourage future efforts in this area of improved access and inclusion of students with disabilities in geosciences, to ensure that those involved have a voice in these projects, from conceptual project design to the final products. With flexibility, creativity, and planning, neurodiverse students can thrive in geoscience programs. Including autistic voices in the process, can provide invaluable insights into understanding their unique needs and building effective frameworks to best support those students throughout their geoscience education career.

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