Universal Design for Learning in the Geosciences for Access and Equity in Our Classrooms

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Universal Design for Learning (UDL) is an educational framework that has been employed in K-12 environments and generally improves learning outcomes for a variety of learners; however, its use in Higher Education (HE) to date has been much more limited. Studies of HE geosciences curriculum, including human geography, physical geography, geology, and environmental geoscience, suggest that learning barriers exist for many students, highlighting the need for curricular revision and the implementation of UDL. This paper reviews this literature to argue for increased engagement of UDL principles in geoscience education to create accessible and equitable classrooms. The authors then describe two geoscience courses that employed these principles to highlight the value of implementing UDL in the geosciences to effectively educate students with different learning preferences and needs. We highlight the value of UDL in geosciences, describe barriers that hinder its adoption, and describe best practices and make recommendations for its implementation.

Introduction

The modality of Higher Education (HE) is ever-changing, with current shifts focusing on the blended/hybrid or online formats (Madaus, 2013). Online and hybrid classes continue to grow across all types of HE institutions. Recently, the COVID-19 pandemic has amplified these shifts in course modalities. These instructional methods and course delivery changes are rife with promise regarding increasing accessibility and improving learning outcomes but can also exacerbate existing inequalities within the educational – and broader social – landscape. The educational framework of Universal Design for Learning (UDL) addresses barriers within the learning environment to remedy these issues based on the principle of equitable use.

Within HE, the disciplines within geosciences could considerably benefit from utilizing UDL principles to make education more accessible and equitable. We use the term ‘geosciences’ to capture the breadth of ‘geo’ work, including human and physical geography, geology, and earth sciences. We have included this seemingly wide array of studies into the moniker of ‘geosciences’ as they share a hands-on and applied approach to studying environmental questions. Geoscience work encompasses the myriad ways of examining Earth systems, which includes human-environment interactions. These fields also share the ability to explore a variety of topics through the lens of place, space, and time. Additionally, curriculum across the geosciences prepares students for various professions and further research – necessitating the creation of an inclusive learning environment to meet the manifold set of goals and a diverse student audience.

Throughout this paper, we explore the application of UDL principles in geosciences to argue that the field could benefit from engagement with this framework. Additionally, we explicate and examine the challenges faced in implementing UDL in two courses within a geosciences department. One is a cross-listed undergraduate/postgraduate course focused on intermediate Geographic Information Science (GIScience) topics and taught in-person with online components. The other class is an introductory-level course on the regional geographic approach, taught fully online. Importantly, the first course occurred pre-pandemic, with the second taught during the emergency remote instruction. While we discuss the need for UDL in geoscience education overall, we bring in the temporal aspect of emergency remote teaching as it has highlighted the need for increased accessibility of course materials.

Collectively, these course descriptions highlight the value of implementing UDL in geosciences education to effectively reach students with different learning preferences and needs. Further, applying these principles can increase the flexibility of use, which is especially beneficial in times of unanticipated instructional interruptions such as the COVID-19 pandemic. Overall, the paper argues for the use of UDL principles across all geoscience curriculum to make strides in creating accessible and equitable classrooms.

Universal Design for Learning, and its Implementation in the Geosciences

UDL is both an educational framework and a set of principles based in the science of learning, cognitive psychology, and neuroscience. UDL pushes educators to change the narrative on accommodations “and instead challenge ourselves to create a learning space that might not need to make accommodations in the first place” (Gannon, 2020, p. 75). Stemming from the Universal Design movement in architecture and its seven principles (Connell et al., 1997), the principle of *equitable use* is a fundamental value that underlies Universal Design, and in turn, UDL.

The focus on equitable use pivots UDL away from having a singular emphasis on a learner’s disability status. UDL scholars and activists argue that when we narrow down who we accommodate for, we narrow down access for all (Tobin & Behling, 2018). Our understanding of ‘access’ draws from Ribot and Peluso’s oft-cited discussion within geography, which sees access “as the ability to benefit from things – including material objects, persons, institutions, and symbols” (2003, p. 153). Regarding pedagogy, this means both the right *and* opportunity to utilize education, acquiring course materials, and the means to enter into spaces.

UDL’s goal is to create a curriculum that can be understood and used, regardless of individual learning situations or needs (T. E. Hall et al., 2012; Rose et al., 2005, 2006; Rose & Meyer, 2006). By removing environmental barriers, the greatest range of students can access and engage in learning, instead of focusing on the so-called ‘average’ learner. Awareness of environmental barriers occurs alongside adjustments for individual student needs and abilities to create approachable and navigable learning experiences. It is this attention to creating a just learning environment through removing barriers that leads UDL to be an aid in radically transforming education for all learners (Leconte et al., 2007; Tobin & Behling, 2018; University of Georgia et al., 2017; Venkatesh, 2015).

CAST outlines three main principles of UDL through multiple means of 1) engagement, 2) representation, and 3) action and expression (*CAST: About Universal Design for Learning*, 2020). The ‘multiple means’ signifies that varying modes are used to meet each of these principles. The framework underlies curriculum development (Rapp, 2014) and is a powerful instructional design tool when implemented at the broader programmatic level.

The removal of barriers and use of multiple means includes providing choices for students, including giving students time to access materials, making documents screen reader-friendly, creating/screencasting videos, and thinking about alternative assignments to the old standbys of term papers and final exams. Additionally, these changes help all students - while not everyone may have a disability, we all get sick, learn differently, and have an assorted understanding and history with course content, thus making equitable access a large component in successful course participation (Shaw, 2011).

While frequently employed across the K-12 setting, HE does not fully or even commonly utilize UDL (Crevecoeur et al., 2014; Rao et al., 2014; Tobin & Behling, 2018). Despite this overall lack of uptake, several publications discuss UDL-based instructional design in HE (see Burgstahler, 2013; Jorgenson et al., 2013; La et al., 2018; Rose et al., 2006). Additionally, Al-Azawei et al. (2016) found that courses using UDL principles had higher student engagement and satisfaction. Additionally, the need for creating an inclusive learning environment in postsecondary education has increased with the expansion of online learning and the complications and opportunities this modality brings, even more so during the emergency remote teaching resulting from the COVID-19 pandemic. This points to the necessity for further application of UDL at the HE level, and in the next section, we outline the particular need for UDL's approach in geoscience education.

UDL in the Geosciences

The geosciences are an area of HE that could expressly benefit from a deeper engagement with UDL. The National Center for Science and Engineering Statistics' 2019 report *Women, Minorities, and Persons with Disabilities* (National Science Foundation, 2019) found that people with disabilities (along with other marginalized groups) continue to be underrepresented in fields within science and engineering. There are many structural reasons this occurs, with Mol and Atchison (2019) arguing that the 'exclusive image' geoscience departments project around learning environments and physical ability exacerbates this issue. Additionally, many practices that make up geoscience work – fieldwork, laboratory environments, and assessments – have traditionally been geared towards the typical student. Due to this, Atchison and Libarkin (2013) call for an evaluation of geoscience instruction to improve access. This is important to consider for geoscience students and all students, as it is a common requirement for them to complete a lab course for graduation (Asher, 2001). Making any required field camp/work accessible is not only an ongoing issue in geosciences – including some programs in our department – but raises questions about what counts as geoscience work and learning. With geoscience work shifting towards Geographic Information Systems (GIS) and geocomputational courses, changing requirements from solely field or lab-based classes and incorporating accessible experiences is something programs need to consider. This can help students who cannot access fieldwork and those who do not plan on using field techniques in their professional lives after graduation.

Several published meta-analyses detail the barriers which exist within geoscience education. Carabajal et al. (2017) outline the physical and non-physical barriers students with disabilities face in different situations, including field sites (mobility, hearing, or vision challenges), the laboratory (accessible data, lighting, lack of inclusive experiment protocols), the classroom (two dimensional versus tactile models, accessible course materials, instructor body language), alongside social and institutional barriers (lack of inclusive policies, financial hardship, biases, discrimination). Giles et al. (2020) outline the same barriers but add considerations around students with caregiving duties, harassing behaviors, travel fears/restrictions due to gender identities and sexualities, religious practices such as fasting, or other physical considerations like menstruation. Furthermore, institutional barriers exist for students of color – particularly Black students – but there is increasing attention paid to the dangers of fieldwork due to racialization (Pickrell, 2020; Viglione, 2020).

UDL itself does not address these barriers' root causes – such as racism, homophobia, or ableism. However, its implementation in geoscience curriculum can impel program directors and instructors to examine different learning environments and their existing barriers and make necessary changes. While there has been recent literature on inclusive teaching and UDL in the geosciences, much of it has a tapered focus on the particulars of student performance, fieldwork, and strategies around inclusive spaces for students with disabilities. A noticeable trend is the emphasis and focus on fieldwork, particularly that which occurs away from institutional settings (see Carabajal et al., 2017; Carabajal & Atchison, 2020; Hendricks et al., 2017; Mol & Atchison, 2019; Stokes et al., 2019). This is unsurprising, as fieldwork is almost a ubiquitous degree requirement across geoscience programs and departments (Mol & Atchison, 2019; Stokes et al., 2019), and “the culture of geosciences is inherently focused on fieldwork” (Carabajal & Atchison, 2020, p. 61). Concerns around fieldwork include accessible field design (Stokes et al., 2019), barriers to participation (T. Hall et al., 2004; T. Hall & Healey, 2005), assumption of able-bodiedness (Mol & Atchison, 2019; Nairn, 1999), and the use of instructional aids trained in disability services (Hendricks et al., 2017). A subset of geoscience instructors has been working towards making assessments and class environments more accessible. Wilson et al. (2011) used computer software to create formative assessments for students to exercise autonomy over their learning, following UDL’s principles of multiple means of engagement and action. Asher (2001) describes the planning and accommodations used to make their classroom accessible to a visually impaired student, which also created benefits for the entire class through more in-depth descriptions in presentations and the use of audio files they could listen to before or after class.

However, these tapered applications of inclusive courses could benefit from further discussions focused on building geoscience curriculums that are accessible to all by design and not just when a student has a disability. Carabajal et al. (2017) found a lacuna in geoscience literature documenting evidence of the effectiveness of overall inclusive teaching. Feig et al. argue that not only do most geoscience instructors have insufficient knowledge of disabilities but also have difficulty "reconcil[ing] accommodation with field[work] learning goals" (2019, p. 66). Fairfax and Brown (2019) echo this, arguing that not only is there a lack of training around this issue amongst geoscience instructors, but that lack, in turn, serves to create a discouraging learning environment for students.

Furthermore, much of the literature does not focus on the roadblocks experienced when trying to implement UDL. While they talk about the need for inclusive education and changes in fieldwork, assessments, and training, there is a gap in the discussion about the explicit engagement of UDL principles in building geoscience courses or programs. Our paper seeks to address this gap by discussing our experiences building different geoscience classes, including the temporal distinctions of pre- and post-COVID-19 pandemic teaching and issues we experienced trying to create a more equitable and accessible classroom. We hope this contribution will continue the discussion of inclusive teaching in geosciences and help instructors consider UDL principles to move past the somewhat constricted focus on disabilities and instead focus on creating an equitable classroom for all.

Description of Courses

In the described courses below, we observed several learning barriers. Amongst our students' caregiving responsibilities, full-time jobs, and/or heavy course loads limited time and energy to devote to specific courses. highlighting the need for increased flexibility in accessing material and student engagement. Monetary issues are also abundant, such as requiring expensive texts, laboratory manuals, and/or software to complete and be successful in the course. Technological constraints may be exacerbated by online or emergency online instruction, such as the requirement to access specialized software or interact with coarse materials on various devices with varying operating systems and screen sizes. Such barriers further complicate computer and data literacy issues and take away from the student’s ability to focus on key course materials and concepts. Some barriers noted above that are of particular concern in the geosciences were not an issue in our classes; for example, our courses do not have field components or laboratory experiments. Therefore, our description of courses and the following discussion revolves around these barriers within classroom accessibility.

100-Level Geography Course

Geography 102: World Regions is an undergraduate course designed to introduce students to geography by examining the interconnectedness of people, places, and systems in major world regions. Students of varying stages and degrees commonly attend the course, as it is a requirement for undergraduate Geography majors and non-majors to use it to fulfill general education requirements. This leads to an assemblage of students across knowledge, experience, and abilities. Therefore, learning barriers arose from many sources, such as issues accessing material across devices, WIFI or broadband outages, to physical or cognitive challenges alongside caregiving or employment commitments.

Within our department, the course traditionally consists of a large in-person lecture and occasionally as an online option but also occurs in a condensed 6-week course over the summer term. This course was taught in the Summer of 2020, originally planned for in-person over six weeks but shifted online following the COVID-19 pandemic outbreak. The instructor used the ADDIE model to assess learner needs and possibilities of course delivery, then design and integrate materials, implementing objectives, with formative assessments throughout the course (Branch, 2009).

To gauge the learner population, students took a poll before the course to gauge needs and preferences, particularly concerning issues of technological access and shifting social/vocational obligations because of the pandemic. The poll questions doubled as a way to provide options for recruiting curiosity about course material to optimize choice, autonomy, and interest in the course to stimulate effective networks (CAST, Inc., 2018). Students for this course were primarily engaged with employment or caregiving duties on top of other summer course requirements, necessitating an asynchronous approach to course design and materials. The instructor recorded lectures, tutorials about the learning management system (LMS), and class updates, then posted the recordings to the LMS alongside PDFs of all lectures and reading material. Students also had the option to attend office hours throughout the week if needed. The lecture PDFs, recorded videos, and virtual office hours took place to provide multiple means of representation through alternatives in auditory and visual information and to guide visualization and comprehension of course concepts (CAST, Inc., 2018). These multiple means of engagement and representation were necessary for a learner base who accessed course material through various devices (e.g., smartphones, tablets, or computers).

Suggestions from the UDL literature helped with developing online course materials to optimize the use of readings and lectures, alongside materials able to be used with assistive technologies. This included: using header formats to indicate new sections of the syllabus or presentation, including alternative text for pictures and diagrams, formatting PDFs of the lectures to be accessible (have searchable text, using colors that had sufficient contrast, using URLs instead of hyperlinks), and offering Word documents of materials when able (which may allow students to make fonts bigger, different colors, etc.). Additionally, the course calendar and due dates existed into easy-to-read tables incorporated into the syllabus, LMS, and each week’s presentation. The instructor did this to provide flexibility through multiple means of representation and action and expression, especially in allowing students to customize how information was displayed.

Underlying all assessments was the philosophy of Mastery Learning, which argues that most learners understand the material, but the time this takes varies among learners (Bloom, 1968; Carroll, 1963). Following Bloom (1971) and Guskey (2010), the course was designed to use initial group instruction (via a recorded presentation), the use of formative assessments for progress monitoring (quizzes and discussion posts), and corrective instruction. Students received corrective instruction through a rubric and in-depth feedback on assignments to address comprehension issues. Students were able to take this feedback and resubmit updated assignments, with the goal being that this corrective instruction would aid in both learner comprehension for the specific assignment and class material in the future (Guskey, 2008). This design occurred with the understanding that students were navigating the intricacies of everyday life and the increased pressures and traumatic nature of the pandemic. While mastery-oriented feedback is listed under the engagement column of CAST’s UDL Guidelines (CAST, Inc., 2018), it draws from all three networks of UDL. In designing this course, mastery learning helped build student perseverance, comprehension of material, and increased executive function through the opportunity to track their progress on an assignment.

Additionally, the instructor supplied course materials in a way that aspired to be read and/or downloaded on all types of devices (desktop/laptop, tablet, or smartphone). Lectures were recorded using Zoom but then posted on YouTube with the link shared to students via email and the LMS. Quizzes were on Google

Forms so that students could have an easier time accessing them across all devices rather than in the LMS. Perhaps most importantly, the course text was open-access and readable online or downloaded as a PDF to the students' device. Any 'class updates' that necessitated more than a sentence were recorded and shared in the same way as the lectures. Given the learners' need for flexible time access to materials, the instructor designed several methods for navigating material, including a weekly email with all information and links, alongside an organized module system in the LMS. The multiple media used for communication – both between and with instructor and students – allowed students to construct assignments in creative and expository ways.

Cross-Listed Upper-Level Geography Course

Geography 350/550: GIScience is an intermediate-level geospatial science course that prepares undergraduates and graduates to complete more advanced geospatial coursework focused on specific topics, such as spatial analysis, geocomputation and programming, and cartographic design. The course has traditionally consisted of a lecture session and a required, linked weekly lab component, taught in a computer lab and relying on commercial, geospatial software. Students majoring in Geography, Geology, or Environmental Geoscience commonly take the course. Additionally, it serves as an elective for other majors, such as Civil Engineering. Since the course focuses on the use, visualization, and analysis of digital map data in a software environment, learning barriers arise from varying degrees of computer and data literacy. While grasping key concepts and techniques in geospatial analysis, students must also become comfortable working in unfamiliar software environments with datasets not commonly encountered. A basic grasp of college-level algebra is adequate to conceptualize the course's mathematical components; however, lack of mathematical knowledge and spatial reasoning skills can also be a barrier.

Recently, the instructor has experimented with changing the modality of the course. During the Spring 2020 semester, prior to the COVID-19 interruptions, this course occurred as an online lecture component and extended in-person lab session. Each lab section began with a recitation to reinforce the assigned lecture material, followed by a two-hour, hands-on lab session consisting of software-based activities relating to and reinforcing the lecture content. To provide multiple modes of instruction, lecture content was hosted on the instructor's webpage. It consisted of annotated lecture slides generated using the iSpring software, practice, non-graded questions embedded within the modules, and links to short YouTube videos demonstrating key topics. The goal was to accommodate a variety of learners by relying on a variety of media and presentations (Rose et al., 2006).

Generated videos were short (generally less than ten minutes in length) and focused on key and/or difficult concepts. All lab content and required data were also hosted on the course website and were available throughout the semester. The instructor designed the website outside of the LMS using responsive web design to foster accessibility on a variety of devices and screen sizes. Given the wide variety of materials provided, the students were not required to buy a textbook. Grading in the course consisted of short quizzes, a midterm and final exam, graded lab exercises and activities completed during the recitation section, and less-guided lab challenges. Ultimately, the goal was to focus in-person class time on discussion and reinforcement of more complex topics.

Due to the COVID-19 pandemic, the course moved online in the middle of the semester. The fully online delivery resulted in an altered syllabus and course design, which was facilitated by the existing online content (Whittle et al., 2020). The instructor delivered material asynchronously to accommodate student schedules and caregiving responsibilities. Students completed lab exercises independently and were able to schedule time with the instructor and/or teaching assistant for help. The greatest difficulty resulting from the unanticipated switch to online delivery related to the need for specialized software, which students had to install and license on their personal computers. To minimize computer and data science literacy barriers, the instructor and teaching assistant scheduled meetings with individual students using screen share technology, which allowed for real-time troubleshooting and guidance. Plans for the future are to develop substitute lab exercises using free and open-source software alternatives to reduce cost and allow for the lab exercises to be completed on a wider variety of computers and operating systems. However, this has proven to be a larger undertaking, as generating the original lab content, which makes use of commercial software, took several years. Also, since software updates regularly, maintaining multiple sets of exercises using different software environments increases the burden of maintaining the course content long term.

Several components of this course, which rely on UDL principles, stand out as effective. First, the availability of open-source, web-hosted, responsive instructional materials allowed students to interact with the content at their convenience on various devices and spend extra time exploring concepts that they found particularly interesting and/or challenging (Coombs, 2010). The use of guided lab exercises followed by less-guided lab challenges allowed the student to gradually transition to independent spatial problem-solving. Multiple modes of expression, including text- and graphic-based web content, short web videos, in-class discussion, and lab exercises and challenges allowed a varied and effective learning experience (CAST, Inc., 2018). Screen share technology helped manage computer and data literacy barriers.

The Challenges and Promises of UDL in the Geosciences

Despite overall growth in geoscience job markets, recruitment and retention at the undergraduate level continue to be an issue in the discipline, particularly in learners from marginalized and underserved communities (Martinsen et al., 2012; O'Connell & Holmes, 2011; Summa et al., 2017). Summa et al. (2017) geoscience education and curriculum needs to shift towards a focus on overall skill and conceptual acquisition across programs rather than in individual courses. However, we argue that any curriculum changes will not be successful unless barriers within these learning environments are first addressed. Therefore, we believe that geosciences – across fields, programs, and institutions – should adopt UDL to make curriculum more accessible. We follow the reasoning from the Information Resources Management Association (2020) that instructors must provide an inclusive teaching and learning environment for students to succeed. This is particularly salient given the current global circumstances pushing teaching and learning further into the online environment.

But challenges persist in the implementation of UDL, not only in geosciences but also in HE. Our course descriptions show that a mix of institutional, situational, and technological circumstances creates roadblocks to implement UDL principles. Particularly salient was a lack of engagement with UDL principles at both the department and university level. However, this echoes the lack of employment across HE generally (Tobin & Behling, 2018) along with a dearth of research on UDL in STEM HE (Schreffler et al., 2019). This presents challenges in the form of extra time needed to consider existing barriers, how to potentially overcome them, create adjustments, and then implement them. Without institutional support, individual instructors may face barriers themselves in implementing principles to address barriers in their classrooms. While instructors do have control over their classrooms, they still exist within the broader teaching and learning culture at a given institution. Assistance with UDL principles, barrier identification, and creating/implementing adaptations at the institutional level will help instructors to easily implement UDL in courses.

Situationally, despite our planning, we encountered several roadblocks and challenges in implementing certain UDL techniques. One such roadblock – which we both were able to overcome – is access to course materials. For the 100-level course, the instructor wanted a textbook accessible on multiple devices and was screen reader-friendly, along with being financially feasible for students. In the cross-listed 300-/500-level course, there were difficulties with the switch to students using personal devices because of the pandemic. The textbook issue was solved with the help of the Geography Subject Librarian at West Virginia University, who helped locate an appropriate open-access text. The software issue was resolved with general licenses but is being further addressed through the future use of open-access software and remote desktops. Technologically, there were constant issues with adding alternative text to images in course materials and adding subtitles to recorded presentations. While PowerPoint has an option to generate descriptions for alternative text, the quality of these descriptions was not only inadequate but sometimes completely inaccurate. Furthermore, a larger challenge that proved unassailable was the attempt to close caption the recorded lecture presentations. The option in the presentation software would not yield the correct verbalizations, and in some cases, do not operate at all. This could be due to a technological issue with the hardware used, but we found that many others who tried this option also struggled. Attempting to overcome this, the instructor uploaded the recordings to the video-sharing platform and attempted to provide subtitles there. However, the main way of providing subtitles is typing them in, which was not a viable option due to time and resource constraints. These technological problems are wider issues that need attention from not only HE but software companies. Moreover, this also points to difficulties arising from skills gaps in technology (for both instructors and learners), which Lee et al. (2013) point out can create an excessive workload and decrease motivation.

Although these challenges exist, UDL is instrumental in reaching the promise of accessibility across the field of geosciences. The issue of fieldwork is a particular example – which neither of us had as a requirement for within the courses discussed; however, this instructor has organized and taught a fieldwork course in the past. As Dzombak (2020) recently argued, the current stoppage in outdoor and group exercises due to the COVID-19 pandemic can be a pivot point for the geosciences to reconsider these experiences in search of more inclusive ways to obtain learning objectives. She points out that these requirements are not only “outdated at best and biased/exclusionary at worst,” but with the proliferation of interdisciplinary work within geosciences, fieldwork may no longer serve as useful training for our students (Dzombak, 2020, para. 7). We are not advocating ‘throwing the baby out with the bathwater’ in the removal of fieldwork but adjusting the approach and its use as a blanket requirement in programs. For instance, geoscientists who analyze digital data may not find value in the experience, and by implementing UDL principles in fieldwork to begin with – e.g., considering the implementation of multiple means of engagement through virtual or other sensory ‘field’ trips – excises the need to individually accommodate students by making fieldwork broadly accessible.

Regarding the specific challenges linked to our discussed courses, the proliferation of UDL across HE and geosciences, in particular, would help to rectify those situations. While open-access software is becoming more popular, the continued reliance on licensed software creates barriers when institutional technology is not readily available. Additionally, larger shifts in technology (and potentially campaigns from HE for these shifts) can help make alternative text and subtitles easier to implement. Underlying all of this is a proposed institutional employment and support of UDL – including, but not limited to, readily available UDL resources and suggestions for instructors – which can help make the principles a norm within HE and move beyond the need for individual accommodations.

These roadblocks should not be used in service of arguing that UDL as a whole is challenging, rather, we highlight them to discuss the apparent need for further utilization of UDL in geosciences and HE altogether. Additionally, while UDL is beneficial no matter the course's circumstances or modality, our experiences have taught us that it is even more important in the emergency remote teaching of the COVID-19 pandemic. Regardless of the majority of instructors and institutions calling this type of shift online learning, Hodges et al.'s (2020) designation of *emergency remote teaching* as the "temporary shift of instructional delivery to an alternative delivery mode due to crisis circumstances" is more appropriate for these situations. Emergency remote teaching (ERT) contrasts with the training and time invested in the specific instructional design that online learning requires (Nilson & Goodson, 2017). Our discussed courses fall into this designation, as we had to shift them online due to the pandemic. Whittle et al. (2020) propose that for emergency remote teaching to be effective, pedagogy needs to follow available resources and be practicable in implementation. While still not an easy switch, the shift to ERT is marginally easier because UDL principles around multiple means of engagement, representation, and action and expression were already partially in place. Because there were different options for students to access and perceive course material along with an understanding of what barriers in the online learning environment may exist, the ERT portion of the 300-/500-level course and the entire 100-level course were able to be more accessible. However, not all instructors are aware of or familiar with UDL, and many have had trouble quickly shifting material online (Whittle et al., 2020). Therefore, not only does utilizing UDL benefit the geosciences in opening our field to all who want to study it, but the UDL principles are imperative for the current time-related issues of online teaching during a pandemic. Furthermore, this points to the need to teach principles of UDL to instructors teaching at the HE level.

Conclusion

UDL has helped us address barriers within our classes in our personal goals of making education as equitable as possible. By making class design "smart from the start" (Pisha & Coyne, 2001) the courses aimed to remove barriers like accessibility and time constraints through providing screen-reader friendly material, course information and concepts in multiple formats, and flexibility in accessing content which helps students choose the best time for them to learn. This helps to create inclusive environments for *all* students, not just those with disabilities, but those with full-time jobs, parents and caregivers, students from historically marginalized groups, and any other situations which constrain access and concentration. These are important considerations to address the various barriers many students experience, not only in ERT but in Geoscience education as a whole.

While technology is helpful – especially during ERT – it must be used alongside effective teaching practices such as UDL (Bain, 2020; Coombs, 2010; King-Sears, 2009). We have argued that an engagement with UDL helps create more accessible and equitable classrooms, which is of particular importance during the shifts in teaching and learning from the COVID-19 pandemic. Additionally, creating accessible and equitable curriculum is of paramount concern for geosciences, especially considering the continued underrepresentation of historically marginalized groups (National Science Foundation, 2019). Addressing concerns around retrieval and use of course materials, the software necessary for courses, time constraints, and curriculum/course requirements (such as physical fieldwork) will help geoscience instructors to build their classes to be accessible from the very beginning. Focusing on *access* rather than accessibility will help to overcome not only the 'exclusive image' of geoscience programs (Mol & Atchison, 2019) but the very real barriers to geoscience participation.

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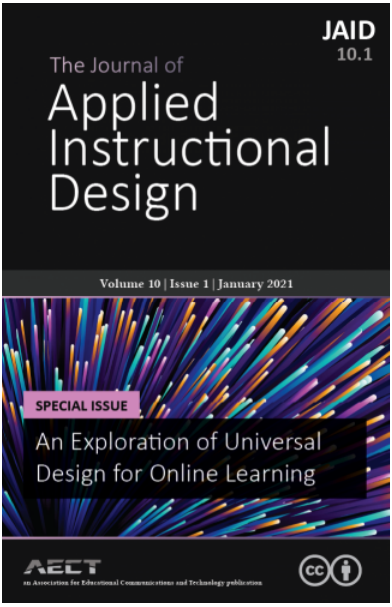

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