Opening the Pathway: An Example of Universal Design for Learning as a Guide to Inclusive Teaching Practices

Hayley C. Orndorf,[†] Margaret Waterman,[†] Donna Lange,[‡] Denise Kavin,[§] Sam Catherine Johnston,[‖] and Kristin P. Jenkins[¶]*

[†]BioQUEST, Raymond, NH 03077; [‡]Information and Computing Studies and [§]Division of Outreach, Placement and Special Projects, National Technical Institute for the Deaf, Rochester Institute of Technology, Rochester, NY 14623; [‖]Postsecondary Education and Workforce Development, CAST, Wakefield, MA 01880; [¶]Texas Institute for Discovery Education in Science, College of Natural Sciences, University of Texas at Austin, Austin, TX 78712

ABSTRACT

Universal Design for Learning (UDL) provides a flexible framework for supporting a wide variety of learners. We report here on a conference that presented the UDL framework as a way to increase success of deaf and hard-of-hearing (deaf/hh) students in introductory biology courses. The Opening the Pathway conference was an NSF Advanced Technological Education project focusing on raising awareness about careers in biotechnology and student success in introductory biology, a key gateway course for careers in biotechnology. The participants were professionals who work with deaf/hh students at pivotal points in students' educational pathways for raising awareness of biotechnology career options, including community college faculty, high school faculty at schools for the deaf, and American Sign Language (ASL) interpreters. The conference goal was to provide an effective, meaningful professional development experience in biology instruction. The conference explicitly addressed the role of a UDL approach in building accessible, inclusive, productive learning environments, particularly for deaf/hh students, and demonstrated how to make effective pedagogical practices, specifically case-based learning, inclusive and UDL-aligned in an introductory biology context. We describe the conference, conference outcomes for participants, and in particular the application of the UDL framework to create an inclusive experience.

INTRODUCTION

The Opening the Pathway to Technician Careers: A Conference for Biology Teachers of Deaf Students (OTP) provided professional development for biology instructors of deaf and hard-of-hearing (deaf/hh) students using the Universal Design for Learning (UDL) framework. This professional development conference provides insights into the value of UDL guidelines for the development of inclusive, flexible learning environments. UDL-informed learning environments are designed to expect and embrace learner variability rather than require learners to adjust how they best learn to match the design of the environment, reducing barriers to learning for everyone. OTP was funded by NSF's Advanced Technological Education (NSF-ATE), a program designed to improve technician education with a focus on faculty and students at 2-year colleges and high schools. The ATE program seeks to increase early engagement and awareness of science, technology, engineering, or mathematics (STEM) topics and careers (Internet Scout Research Group and American Association of Community Colleges, 2018) through a variety of methods, including professional development and workforce development programs. We describe how three organizations, CAST, DeafTEC, and BioQUEST, joined together to explore the impact of applying UDL to introductory biology at the high school and community college levels to improve educational

Kimberly Tanner, *Monitoring Editor*

Submitted Sep 14, 2021; Revised Feb 18, 2022; Accepted Mar 3, 2022

CBE Life Sci Educ June 1, 2022 21:ar28

DOI:10.1187/cbe.21-09-0239

*Address correspondence to: Kristin P. Jenkins (kristin.jenkins@austin.utexas.edu).

experiences of deaf/hh students. CAST is the national leader in UDL and has provided the definitive framework of a UDL approach. DeafTEC is an NSF-ATE center with a mission to increase the number of deaf/hh people in technician careers. BioQUEST is a professional development group with a focus on enhancing interdisciplinary biology education with cutting-edge science and evidence-based pedagogies.

While the OTP conference is an example of professional development organizations leveraging their expertise to apply UDL in a single disciplinary context for a particular educational situation, the lessons learned on the value of professional development in applying a UDL approach are applicable far beyond this specific situation. The development of this project required 2 years of preparation and planning and has provided valuable lessons in designing effective professional development for promoting inclusive teaching in any discipline or educational context.

BACKGROUND AND CONTEXT

Entering the workforce as a technician in STEM is an excellent career option in the United States. Employment for technician positions is projected to grow faster than the average for other occupations through 2028, while also offering salaries above the median wage for all occupations (U.S. Bureau of Labor Statistics, 2021). These technician positions often require only a 2-year degree that can be obtained from a local community college rather than a 4-year or further postsecondary degree (Carnevale *et al.*, 2017). These well-paying jobs are drivers of the economy, essential to the advancement of science, and offer good career options for those with interests in STEM subjects (National Academies of Sciences, Engineering and Medicine [NASEM], 2017).

Unfortunately, many groups of people remain underrepresented in technician careers, including women, people of color, and persons with disabilities (U.S. Equal Employment Opportunity Commission, 2016; Funk and Parker, 2018). The NSF-ATE program aims to expand and diversify the technician workforce to meet industry needs through targeted programming at 2-year colleges (Internet Scout Research Group and American Association of Community Colleges, 2018). Focusing on community colleges provides a direct connection to more than 40% of the undergraduates in the United States and a more diverse student body than is found at most 4-year institutions (Ma and Baum, 2016). ATE programs target students in high school and 2-year colleges to raise awareness of technician careers and to increase inclusion of underrepresented groups in both technician education and the workforce.

One way to increase participation of all students in biology-related careers is improving pedagogical practices in introductory biology, a gateway course to advanced STEM classes required for many technician careers. Improving pedagogical practices in introductory biology can increase engagement and participation, increasing student success (Seymour and Hunter, 2019) and thus lowering barriers to further studies including technical career education tracks. Barriers in introductory biology include suboptimal pedagogical practices (Freeman *et al.*, 2014); disciplinary communication style (Round and Campbell, 2013; Lieu *et al.*, 2017); and a growing emphasis on quantitative skills, including data science, computation, and modeling (Gibson and Mourad, 2018; Helikar *et al.*, 2015; Wright *et al.*, 2019). Some barriers in biology are common to all STEM fields, while others are unique to this discipline, such as the flood of disciplinary vocabulary in introductory biology (Yager, 1983).

These barriers in introductory biology affect all learners, even those who persist (Seymour and Hunter, 2019). There is growing recognition that, in addition to adopting evidence-based teaching practices for core skills and content, faculty must also create an inclusive learning experience wherein more students are able to persist and succeed in achieving their educational goals (Dewsbury and Brame, 2019). A growing body of research provides information about the hallmarks of inclusive practices, independent of disciplinary content. For example, setting aside time to learn about students as individuals and implementing social norms to ensure an inclusive classroom environment are practices applicable to any discipline (Zehender *et al.*, 2021). However, research suggests that evidence-based pedagogical practices may not serve all students equally well (Eddy and Hogan, 2014). This is a particularly salient concern in community colleges, which tend to serve more diverse student populations (Ma and Baum, 2016; Community College Research Center [CCRC], 2021). Furthermore, incorporating inclusive practices in disciplinary contexts and specific pedagogical practices presents additional challenges. For example, case studies are an effective pedagogical practice, but instructors must be aware of what type of case will resonate with their students and include characters with whom their students can relate (Smith *et al.*, 2012).

UDL provides a framework for incorporating inclusive teaching practices to create flexible, contextually appropriate learning environments that plan for learner variability, better supporting all learners (Meyer *et al.*, 2014). UDL encompasses a range of ideas and instructional strategies. Application of UDL principles in any given discipline to achieve particular educational learning goals requires careful selection of appropriate evidence-based practices to provide the most flexible learning environment possible within the constraints of resources, technology, and time. For example, having students demonstrate mastery by writing a final paper is appropriate when writing in the discipline is one of the course learning outcomes. Otherwise, UDL suggests offering multiple options, such as writing a letter to the editor, giving a prerecorded presentation, or staging a debate. Another example of a UDL strategy is providing alternatives for auditory information. For example, in a large lecture, this would mean ensuring all multimedia clips shown in class are appropriately captioned. This provides critical access to content for deaf/hh learners but also benefits learners whose first language is not English and provides an introduction for new vocabulary words for everyone.

LEARNER VARIABILITY AND DISABILITIES

A growing number of undergraduates report having a physical or cognitive disability, particularly at 2-year colleges (Skomsvold, 2014; Campbell and Wescott, 2019). The National Center for Education Statistics report on undergraduate demographics for the 2011–2012 academic year found only 11% of undergraduates disclosed disabilities (Skomsvold, 2014), but in the most recent report for the 2015–2016 academic year, that number had risen to 19% (Campbell and Wescott, 2019). Additionally, some demographic groups have higher rates of disabilities. For example, among veterans attending college,

42% of whom attend community colleges, 26% report having a disability (Campbell and Wescott, 2019, pp. 6, 134). Students over 30 years old report higher rates of disabilities at 22–24%, and 45–50% of these students attend community colleges (Campbell and Wescott, 2019, pp. 6, 133). It is likely that the actual number of students with disabilities is underreported for a variety of reasons, including undiagnosed disabilities or fear of stigma (Horowitz *et al.*, 2017; Shaewitz and Crandall, 2020). Despite this increasing number of students with disabilities, many of our educational institutions continue to design spaces, courses, and learning experiences in adherence to the medical model of disability. This model deems impairments, traits, and characteristics of individuals as inherently disadvantageous (Oliver, 1983; Oliver and Barnes, 2010). The deficit approach of the medical model is often reflected in language used to describe traits, such as "hearing impairment."

There are 70,000 children in the United States who are designated as having a hearing impairment (Office of Special Education and Rehabilitative Services [OSERS], 2021). This label does not tell us anything about these learners beyond their hearing status; it provides no information about their culture, language, experiences, or communication preferences. There is great variability in this small population of learners that is often overlooked. Data indicate that 80% of these students spend the majority of the school day in traditional school settings, while 20% attend schools for the deaf (Nagle *et al.*, 2016; OSERS, 2021). There is variability in their language fluency; for example, some are fluent in both English and American Sign Language (ASL), some in only one language. There is variability in preferred modes of communication (spoken vs. signed), adding additional layers (Marschark and Wauters, 2008; Dostal *et al.*, 2017).

The perspective typically presented in contrast to the medical model is the social model of disability. This model explores how society and the design of environments create disadvantages, rather than focusing on how traits or characteristics of individuals are "disabling" (Oliver, 1983; Oliver and Barnes, 2010). For example, imagine attending an event in the Deaf community where ASL is the main mode of communication. At this event, the only people at a disadvantage are those who are not fluent in ASL. The social model of disability can explain how traditional educational settings in the United States that are designed for hearing learners can put deaf/hh students at a disadvantage.

While the effects of primarily thinking in terms of the medical model of disability might be more pronounced in deaf/hh students (Humphries, 2013), learner deficit mindsets of any kind are harmful to all learners (MacFarlane, 2018). Consider the seemingly innocuous approach of designing learning experiences for "average." Designing for an average student ignores the variability between and within learners, requiring everyone to overcome barriers to succeed in the environment. The concept of a "jagged profile" (Rose, 2016) more accurately reflects the reality of student abilities. A jagged profile acknowledges that any given person falls above the average on some traits or characteristics, and below in others. Learning environments that are narrowly designed to effectively serve the "average" student allow for fragmented success without supporting the whole learner.

UDL provides an alternative approach aligned with the social model of disability. It encourages designing for variability from the outset, abandoning the false concept of "average." In educational environments focused on removing unnecessary barriers to learning, all students, including those with disabilities, are better supported to engage in productive learning.

UNIVERSAL DESIGN FOR LEARNING

UDL originated from the architectural concept of "universal design"—the idea that thoughtful design of an environment can make it more useful to more people (Connell *et al.*, 1997). Universal design leads to spaces that simply make sense for everyone, while providing critical access for some. Curb cuts, for example, are critical in making sidewalks accessible to someone in a wheelchair; however, they are also extremely convenient for someone on a bike, pushing a stroller, or hauling wheeled luggage. The UDL framework was developed by CAST in 1990 and promotes a similar idea for learning environments. CAST's UDL framework focuses on "improving and optimizing teaching and learning for all people based on scientific insights into how humans learn" (CAST, 2018), which considers both the physical space and pedagogical practices that combine to create the holistic learning environment. UDL helps faculty plan for predictable variability in students by presenting strategies for designing more inclusive learning environments. Addressing barriers to learning through a UDL approach entails preserving productive challenges that are required for learning while removing unnecessary barriers in the learning environment through flexible, adaptable design. In a community college setting, where faculty may be presented with multiple accommodations for learners with disabilities in any given class, beginning from a learning environment in which many barriers have already been removed can reduce or lessen the need for individual accommodations. Meanwhile, all students in the course benefit from increased flexibility.

UDL is based in neuroscience and education research and was originally focused on developing technology-driven accommodations to provide accessible experiences for learners with specific disabilities (Meyer *et al.*, 2014). This focus on accessibility aligned with legal definitions of the term; a person with a disability must have complete and equal opportunities as compared with a person without a disability (Rehabilitation Act of 1973). CAST quickly realized that deliberate design of learning environments to anticipate learner diversity provided more benefits to a wider range of people, effectively planning for predictable variability regardless of ability (Meyer *et al.*, 2014). For example, providing multiple representations of audio content through captions and transcripts provides critical access for some but benefits all learners (Meyer *et al.*, 2014; Gernsbacher, 2015).

The UDL framework is organized to correspond with cognitive networks and learner development. (A condensed version of the framework is depicted in Figure 1. The full framework and supporting documents are available at https://udlguidelines.cast.org.) The columns represent the three main principles of UDL: providing multiple means of engagement, representation, and action and expression. The goal of UDL, described in the final row, can be summarized as developing learners who have the metacognitive skills to adjust and thrive in any learning environment (Meyer *et al.*, 2014). The rows in the framework

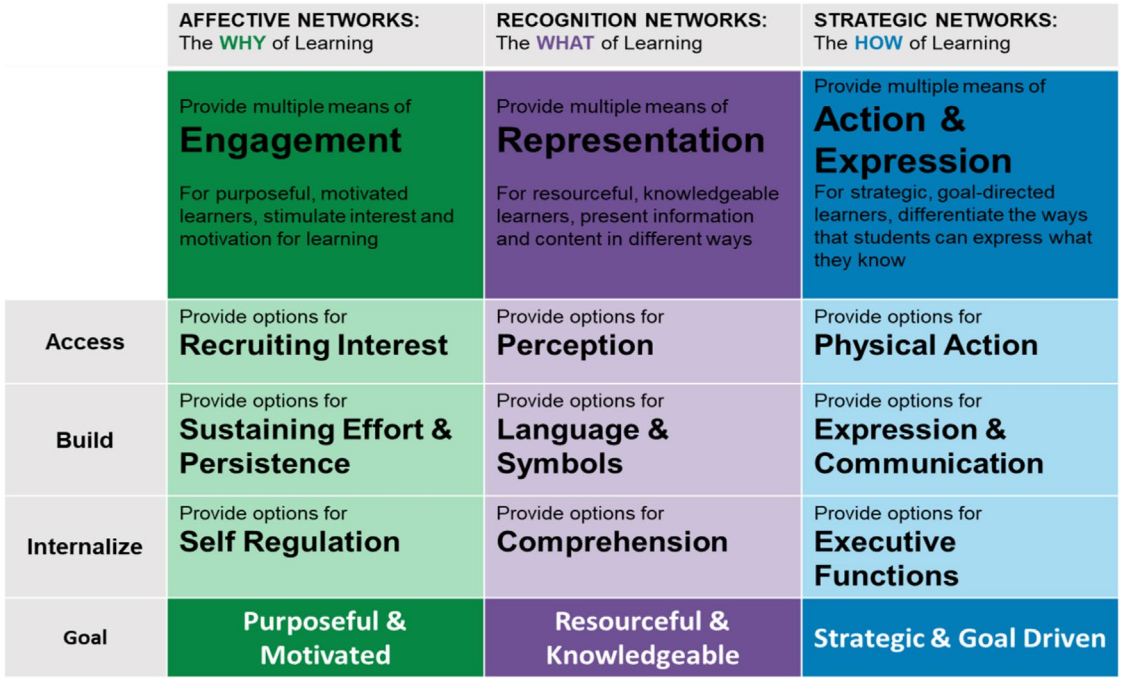

FIGURE 1. The UDL Framework: This figure shows a condensed version of the UDL guidelines. The three principles of UDL address affective, recognition, and strategic cognitive networks by providing multiple means of engagement, representation, and action and expression. Learners' ownership of their own learning is reflected in the rows, ranging from ensuring all learners can access information through full realization of self-regulated learning. The full figure contains 31 checkpoints that guide instructors in selecting strategies to optimize challenges and remove barriers. The UDL guidelines should not be considered a "checklist for UDL"; rather, they present instructional approaches that should be implemented strategically according to one's context and learning goals. An interactive version of the full figure is available on the CAST website (CAST, 2018), and connects to a rubric that explores each aspect more deeply (Novak and Rodriguez, 2018).

build toward that goal by identifying levels of learners' ownership and management of their own learning.

The three main principles, represented in the columns (Figure 1) are based on engagement of the affective, recognition, and strategic cognitive networks to ensure all learners can access and fully participate in the learning environment. Each column has three rows that provide guidelines ranging from a focus on basic access to supporting higher order internalization of metacognitive skills. The columns are:

- **Engagement:** Guidelines range from minimizing threats and distractions in the learning environment to empowering learners' ability to identify relevance and interest.
- **Representation:** Guidelines range from the option to use different senses when interacting with the learning environment through providing opportunities to apply prior knowledge and transfer knowledge in new areas.
- **Action and expression:** Guidelines range from offering alternatives in the physical mode of response (e.g., students can write, type, or record a response) through practice in building executive functions that promote development and application of learning strategies.

The rows in the framework identify levels of learners' ownership and management of learning that are facilitated by UDL practices. These levels are:

- **Access:** This is the fundamental but essential level of UDL that ensures learners can physically engage with materials; it is where traditional accessibility is addressed. Access also includes ensuring that the learning environment provides relevance and authenticity for students and using technology that is designed for a broad range of users (e.g., options for using mouse commands *and* keyboard shortcuts).
- **Build:** This is where traditional content knowledge mastery occurs. This level is where faculty provide learning environments that support students' persistence, provide disciplinary expertise by clarifying and "decoding" disciplinary information, and scaffold students' ability to demonstrate mastery of disciplinary practices.
- **Internalize:** This level focuses on the development of higher-order learning and metacognitive skills that support students in becoming experts in how they learn. Skills in this row include self-regulation, developing coping skills and strategies, ability to transfer knowledge across domains, engagement in disciplinary core concepts, and the application of appropriate metacognitive practices to enhance learning.

Physical and cognitive access for instruction are just the first steps in universally designed learning spaces and materials. The engagement focus of UDL aligns with inclusive teaching practices by leveraging students' unique backgrounds and experiences to improve success and by reducing threats and distractions in the learning environment. UDL fosters development of executive functioning that allows independent learning, such as goal setting and planning (Earley, 1985; Fuchs *et al.*, 1989) and

strategy development (Baker *et al.*, 2002; Dawson and Guare, 2018). A UDL approach does not prescribe an entire overhaul of one's teaching practice or dictate specific methods or pedagogies, nor should the UDL framework be used as a checklist (Basham *et al.*, 2020). Rather, a UDL approach focuses on iteratively applying UDL to improve a curriculum, steadily reducing barriers and enabling student learning (Tobin and Behling, 2018).

UDL advocates for the removal of unnecessary barriers to learning. A common example of an unnecessary barrier is the time allotted for examinations. Most examination times are determined by class schedules and room availability rather than a purposeful time allotment for completing the assessment. Increased flexibility in the time allowed to complete an exam would alleviate the necessity for the common student accommodation of additional testing time while preserving the productive challenges in the assessment, namely, demonstrating mastery of the content. A UDL approach to timed exams provides a physical space that is available for an extended period of time. Allowing even 2 hours for an exam the instructor feels could be completed in 1 hour changes the focus to demonstrating content mastery, rather than how well students can manage time or how quickly they can answer questions. DeafTEC's workshops for educators and employers (e.g., Project Access, Working Together: Deaf and Hearing People, Writing in the Disciplines, and Promoting Student Success in Math through Best Practices) provide additional examples of UDL practices that are essential for deaf/hh individuals but improve experiences for everyone. For example, in one workshop activity, auditory recordings of isolated words are played, and participants write down what they heard. As the recordings vary in volume and clarity, very few people are able to accurately identify all of the words. This activity is followed with several suggestions for clear communication, some as simple as always facing the audience when speaking to avoid the muffled sounds and blocked sight lines that occur when the instructor speaks while facing the board.

Thus, a UDL approach begins by identifying a specific learning goal and preserving the productive challenges and struggles that are essential to meeting that learning goal, while offering options in the means to reaching the goal. The UDL framework then acts as a structure for incorporating evidence-based pedagogical practices grounded in learning and neuroscience research (Rose *et al.*, 2006; Meyer *et al.*, 2014; NASEM, 2018). UDL can provide a lens for understanding why particular pedagogical strategies do or do not work in certain circumstances and ways to mitigate shortcomings in the pedagogical practice, including creating a more inclusive learning environment.

OPENING THE PATHWAY CONFERENCE

Opening the Pathway to Technician Careers: A Conference for Biology Teachers of Deaf Students was held October 13–15, 2019, at the National Technical Institute for the Deaf (NTID), one of the nine colleges of Rochester Institute of Technology (RIT) in Rochester, New York. NTID is the first and largest technological college in the world for deaf/hh students, and the administrative home of DeafTEC. The OTP conference sought to improve outcomes for deaf/hh students in biology by offering professional development to individuals who work with deaf/hh students. The goals of this conference were 1) provide an effective, meaningful professional development experience in biology instruction for a diverse group of participants from community college and high school settings; 2) explicitly address the role of a UDL approach in building accessible, inclusive, productive learning environments in introductory biology, particularly for deaf/hh students; 3) demonstrate how to make effective pedagogical practices, specifically case-based learning, inclusive and UDL aligned in an introductory biology context; and 4) increase educators' awareness of biology-related technician careers.

Participants

The OTP conference was designed to engage professionals who work with deaf/hh learners in a UDL approach. These professionals included 19 high school science teachers from schools for the deaf; 13 biology faculty from 2-year institutions; nine ASL interpreters who specialize in high school or postsecondary settings, particularly with some STEM interpreting experience; and two college administrators. These individuals play different roles in the educational pathways of deaf/hh students and have different professional preparation and expertise. High school instructors are a critical component of the technician career pipeline and need to be familiar with imminent career pathway opportunities available to their students. Community college faculty teaching introductory biology are ideally situated to inform students about biology-related technician career pathways at their institutions and to connect interested students with campus resources. ASL interpreters work in both high school and community college settings to facilitate communication between instructors and students. It is not feasible for interpreters to have a background in each topic for which they interpret; as such, interpreters in science education often need to learn the biology vocabulary in addition to interpreting it (Hauser and Hauser, 2008; Solomon *et al.*, 2012; Braun *et al.*, 2018), and as mentioned previously, biology in particular requires mastery of a large volume of discipline-specific terminology.

The variability in participants' roles, languages, backgrounds, and expertise required the design of a bilingual, inclusive conference that not only presented UDL as a topic but was UDL aligned in its design and programming. For example, participant communication preferences, which ranged from ASL to spoken English, provided an opportunity to demonstrate the UDL principle of providing multiple means of representation. All presentations and panels were interpreted either from ASL to English or vice versa. Videos were captioned, and directions for activities were provided in handouts, in ASL and English, and via a PowerPoint slide. Participants also varied in their familiarity with Deaf culture, providing yet another opportunity to apply UDL practices to create relevance for all participants. For example, ASL is a visual language, so preserving sight lines is critical for effective communication; this required practice and reminders for those not familiar with Deaf culture. There was also substantial time dedicated to group work and socializing for a productive exchange of ideas and community building. Pedagogical approaches with a "low floor, high ceiling" (NRICH, 2019) were used to introduce biological content knowledge in ways that allowed all participants to engage and meaningfully contribute regardless of their biology backgrounds. ASL interpreters were able to participate in all the biology education

activities because of this open approach. UDL and the pedagogical practices were explicitly identified, described, and demonstrated so that all participants were working from a shared understanding of these practices. This helped address the misconception that UDL and good pedagogical practices are interchangeable.

The conference planning team from CAST, DeafTEC, and BioQUEST brought perspectives from diverse institutions and had a range of biology backgrounds and varied fluency in ASL and familiarity with Deaf culture. The variety of representation on the planning committee was crucial to the success of the conference; however, it required more than 2 years of planning to nurture this conference from an interesting idea to fruitful experience. During these 2 years, the planning team from CAST, DeafTEC, and BioQUEST met in person and online to develop the outline and basic content of the workshop. In addition, a group of advisors with a high familiarity with Deaf culture and community college teaching experience met with the planning team throughout the process to provide feedback on the workshop content and programming. The advisors played an active role in the workshop by presenting educational resources they had developed and leading several of the case sessions.

Programming

The programming included keynote addresses, panel presentations, exploration and work sessions, periods of group work time, and significant opportunities for social engagement. The conference programming was divided into four major session types that addressed conference goals.

Keynote Presentations

The keynote presentations addressed topics that included intersections of Deaf and science identity, ASL STEM signs, and the importance of culturally relevant mentoring, with connections to biology in each. The first keynote presenter, Dr. Barbara Spiecker, shared her experience as a Deaf scientist in marine ecology. She emphasized the importance of adjusting environments to promote student success rather than focusing on changing learners. Dr. Spiecker shared suggestions for improving education of deaf/hh students, drawing from her personal experiences as a deaf/hh graduate student and scientist. The second keynote was Dr. Christopher Kurz, a professor at NTID who specializes in mathematics, science, and Deaf education. He led a lively discussion about academic ASL and STEM vocabulary in ASL. Accurate and effective bilingual communication around STEM topics is critical in deaf/hh education; Dr. Kurz emphasized the importance of using data-driven techniques in selecting STEM signs and strategies such as "concept first, vocabulary second." Our final keynote presenter was Dr. Derek Braun, professor of biology at Gallaudet University. Dr. Braun shared research he and colleagues conducted on developing Deaf students' science identity through mentoring. While Dr. Braun's work focused on deaf/hh students, these findings are relevant to faculty working with all types of underrepresented students. Dr. Braun presented key factors in mentoring deaf students, including awareness and understanding of Deaf culture, teaching self-advocacy, and building cohorts that avoid isolating a single minority representative (Braun *et al.*, 2017, 2018). One finding Dr. Braun shared was the greater success of mentors who were familiar with Deaf culture, because these mentors were able to encourage mentees to connect with Deaf community resources and proactively support mentees' communication access and development of self-advocacy. Like other cultural communities, the Deaf community has a rich culture that is nurtured in social interactions through clubs, schools, and shared language (Braun *et al.*, 2017). Access to this cultural wealth can enhance mentees' success in several ways, including networking and reducing a sense of isolation. Hence, a mentor's awareness of a mentee's culture is an important factor to address in efforts to increase diversity and inclusivity in STEM fields.

Panels

Panels included professionals in the biotechnology workforce as well as current NTID students and included information about biology-related technician careers, describing what those careers entail, and Deaf technicians' experiences in these fields. The panels highlighted the variable educational routes learners might take to technician careers, providing valuable information for participants to share with their students. Resources, such as the InnovATEBIO Center, which is a national ATE center that provides training and information about biotechnology careers specifically, were also shared.

Case-Based Learning Sessions

These sessions introduced participants to case studies, a pedagogical approach that involves engagement in scientific investigation and the development of analytical thinking about real-world problems (Stanley and Waterman, 2000; Waterman and Stanley, 2008). Case pedagogy also builds collaborative learning skills and communication skills and promotes active learning, all of which align with the UDL framework (Herreid, 1994; Herreid *et al.*, 2011; Thistlethwaite *et al.*, 2012; Meyer *et al.*, 2014). Case sessions were designed using a UDL approach to be inclusive of the wide range of conference participants. Case studies were presented in ASL and English and in multiple media, including written English, spoken English with ASL interpretation, and a video in ASL with English captions. The topic of the central case study was genetically modified organisms (GMOs). All participants engaged with this case as learners regardless of their biology background and all participants could contribute ideas and identify questions to explore that held personal interest. After engaging with the case as learners, participants returned to their educator perspective, prepared to explore and design solutions contextualized for their learners and classrooms. Sessions later in the conference explored supplemental activities for the case study, such as ideas for structured exploration of websites on GMOs, creation of basic genetic models to create "marshmallow bug babies," and a low-cost gel electrophoresis simulation (see Supplemental Material to access activities). Participants were encouraged to consider the UDL alignment of these activities and how they might be further modified for their own classrooms. Sessions concluded with an opportunity for reflection about the educational and biology content and participants' own learning.

Group Work

Participants were tasked with designing an activity for their students using a UDL approach and case pedagogy. Groups formed

based on participants' interests, and they were encouraged to use their new knowledge and skills in biology and UDL to design an activity for their classrooms. Participants were highly engaged in this activity because it was personally relevant, and the group work generated a creative exchange of ideas leading to activities that were well informed, resource rich, and appropriate for specific educational settings. Participants discussed how they would use particular activities in their classrooms, modifications that they would make, and shared resources to make activities better for their classrooms. OTP concluded with each group presenting on the activity they had designed, its connections to case pedagogy, and how it was UDL aligned. Group members participated in sharing their work supported by PowerPoint presentations and models. Group members also shared the different ways they planned to use the materials in their individual classrooms. This final session was a critical component in which individuals solidified their own learning by presenting to others, and the community benefited from shared resources, materials, and ideas.

In addition to the formal structure, OTP included a substantial amount of time for informal interactions including meals, breaks, entertainment, and casual conversation. This dedicated informal time in a purposeful and welcoming environment facilitated connections between participants across cultures and languages. For example, participants shared the experience of a performance by the Sunshine 2.0 theater troupe. This group engages deaf and hearing audiences with STEAM ("STEAM" acknowledges the addition of the arts to STEM) topics by combining theater, dance, music, and spoken and signed languages. This cross-cultural and bilingual production provided a space for OTP participants to explore ideas together through performance art. These opportunities to build relationships and trust heightened the productivity of group work time, leading to increased flow of ideas and sharing of practices (Polanyi, 1962; Pyrko *et al.*, 2017).

Evaluation

The evaluation, led by Peggie Weeks (Lamoka Educational Consulting), consisted of daily participant reflection surveys, two participant focus groups, an end-of-conference participant survey, and a Plan for Change survey, all completed during the OTP conference. Additionally, a Plan for Change Follow-up Survey was sent to participants in October 2020, 1 year following the conference. The response rate for evaluations conducted during the conference was generally greater than 85%, although this varied by day and question. The evaluation results suggest that the OTP conference was successful at meeting its outlined goals, as detailed in Table 1.

The Plan for Change Follow-up Survey reminded participants of their initial plan for change and asked participants about the extent to which they were able to accomplish the plans they set during the OTP conference, how well the conference supported their teaching and interpreting, and the utility of workshop resources. Despite the COVID pandemic, the survey had an overall 67% response rate, with an instructor response rate of 73%. Many respondents reported being able to accomplish what they had planned (82% strongly agree/agree), that these changes worked well in practice (71% strongly agree/agree), and that their teaching/interpreting was more effective as a result of the conference (80% strongly agree/agree). Respondents noted that they observed increased student engagement (79%), as they used the resources from the conference (88% strongly agree/agree), specifically applying UDL principles (86% strongly agree/agree) and case studies (73% strongly agree/agree). Although the conference preceded the pandemic and did not address the kinds of changes required by the rapid shift to online instruction, respondents felt they were better prepared for the challenges presented by this shift in educational modality, and 92% strongly agreed/agreed that they were better prepared to meet the needs of their students as a result of the conference. We feel that this response is based on the application of UDL to the new situations presented in the pandemic. The purpose of UDL is to provide more flexibility in the learning environment and to create learning environments that support a wide range of student needs. Only 16% of respondents did not feel that the conference had prepared them to better adapt to teaching in the pandemic. More results of the follow-up survey are reported in Table 2.

CONCLUSION

The OTP conference sought to improve biology education experiences for deaf/hh students by providing professional development to high school teachers, college faculty, and ASL interpreters. This conference was an ideal example of how inclusively designed learning environments support variable learners, and importantly, how the context plays a critical role in considering which design choices will be necessary to include all learners. In the context of the OTP conference, a UDL approach allowed the development team to create a more inclusive environment for our participants that addressed the expected variation in their backgrounds across familiarity with Deaf culture, ASL fluency, and biology content knowledge. For example, biology teachers at schools for the Deaf were likely fluent in ASL and experienced with Deaf culture, interpreters, while also fluent in ASL and knowledgeable of Deaf culture might have a limited background in biology, whereas a community college faculty member might have a strong background in biology but lack fluency in ASL.

OTP programming needed to be inclusive of this variability in all aspects of the conference, including pedagogical approaches, educational resources, and communication facilitation. The development team's UDL approach ensured information was accessible in each participant's preferred language by providing interpretation services for every aspect of the conference, including breakout groups and social situations such as meals. Participants unfamiliar with Deaf culture learned Deaf cultural practices, such as keeping clear lines of sight for communication. We were also addressing multiple educational settings ranging from combined grade-level general science courses to specific subfields within biology. The biology content had to be engaging and accessible for novices and experts and useful for students ranging from high school to college. The case pedagogy we chose to present is particularly useful in engaging a diverse audience. In addition, by demonstrating UDL practices and explicitly discussing the UDL practices in play, we provided participants with an authentic experience in the value of UDL, so when we invited them to apply these principles in their own classrooms, they were already convinced of the value.

Professional development on adopting a UDL approach is particularly relevant for community college faculty who are serving diverse groups of students and meeting a wide range of student needs. However, few undergraduate faculty have access

TABLE 1. Conference goals and associated evaluation results collected during OTP

Conference goal	Evaluation results
Goal 1: Provide an effective, meaningful professional development experience in biology instruction for a diverse group of participants from community college and high school settings.	At the conclusion of OTP, > 80% of respondents, who included 2-year faculty, high school teachers, and ASL interpreters, felt better prepared to integrate or support the integration of case-based pedagogy and UDL in biology classrooms. All responding participants were excited to be a part of a community focused on deaf/hh biology students. Participants also noted several ways to improve the experience, including more programming on ASL STEM signs, offering some targeted sessions for participants new to Deaf culture and the Deaf community, and offering a longer conference with shorter days for more time to explore the topics of the conference while reducing the cognitive load of each day. High school teacher: "I loved the diversity of the participants! Having a broad representation of the many stakeholders was insightful and significant. It broadened my perspective tremendously." A community college faculty member on the most useful part of the conference: "Immersion into the community of teachers and interpreters in the Deaf communities [was] fantastic and rare!"
Goal 2: Explicitly address the role of a UDL approach in building accessible, inclusive, productive learning environments in introductory biology, particularly for deaf/hh students.	More than 85% of respondents felt better prepared to either integrate or support the integration of UDL practices in classrooms. Learning about UDL was also cited as one of the most useful parts of the conference. Keynote presentations were also essential in achieving this goal and well received by participants, many noting that they now have a better understanding of both the challenges and resources available for deaf/hh learners. Interpreter: "For me the most useful part of this conference was the case-based pedagogy and UDL principles. I will apply that to my life and my career."
Goal 3: Demonstrate how to make effective pedagogical practices, specifically case-based learning, inclusive and UDL aligned in an introductory biology context.	Participants noted that OTP provided them with tools and resources that equipped them to improve outcomes for their learners and self-reported increases in knowledge about case-based pedagogy and UDL. Participants also mentioned specific practices in their plans for change that align with case pedagogy and UDL, including: • Implementing case studies and case analysis approaches • Designing more flexible assignments • Building more collaborative relationships between instructors and interpreters • Ensuring that deaf/hh students have access to information in ASL and English
Goal 4: Increase educators' awareness of biology-related technician careers.	While the self-reported increases in knowledge about technician careers were smaller than those for UDL and case pedagogy, participants' comments about programming focused on increasing their awareness of biology technician careers were positive; they particularly valued the multiple perspectives represented on the panel and felt the information would be beneficial for their learners. Participant: "Very informative and impressive—I plan to check on links: BioTech-careers.org and Bio-link.org to see what resources can support me and my students for biotech careers."

to sufficient professional development to support the kinds of educational reforms needed for improving STEM education outcomes (Brownell and Tanner, 2012; President's Council of Advisors on Science and Technology, 2012), even at community colleges, where education is emphasized. The OTP demonstrated the value of UDL in building learning environments and gave participants an opportunity to explore applications of UDL in their own classrooms.

The comprehensive and flexible approach to teaching that UDL provides is especially helpful in developing an inclusive teaching philosophy. We believe that widespread adoption of a UDL approach by professional developers and STEM faculty will ultimately have a beneficial effect on students through increasing inclusive practices, leading to greater diversity in STEM education and professions, and importantly, focusing on supporting the growth of lifelong, self-directed learning. Shifting from the perspective of learner deficits as barriers to learning to a model that critiques the design of environments as enabling or disabling creates more inclusive classrooms for everyone and provides educators with the resources to adapt learning environments in a contextually appropriate manner. The more purposefully and inclusively designed learning environments are, the better equipped all students are to succeed and the fewer accommodations faculty need to retroactively fit into their courses. The OTP conference offered professional development for instructors and interpreters of deaf/hh students with the aim of improving biology education experiences at the introductory level. Although the population of deaf/hh students in the United States, particularly in postsecondary education, is relatively small, improving biology education practices for students who are deaf/hh provides an excellent example of how using a UDL approach to create more inclusive learning environments can improve outcomes for all students.

ACKNOWLEDGMENTS

This paper is dedicated to the memory of our colleague, Melissa Skyer, whose friendly disposition, wisdom and sense of adventure will be sorely missed. The authors are grateful to the advisors: Brandon Call, Sandi Connelly, Vedham Karpakakunjaram, Viet Le, Melissa Skyer, and Barbara Spiecker. The authors also wish to thank the National Technical Institute for the Deaf and Rochester Institute of Technology for hosting the meeting. This conference was supported by the National Science Foundation's Advanced Technological Education Program (ATE) under award numbers 1834905 and 1834913. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

TABLE 2. Conference goals and associated evaluation results from the Plan for Change Follow-up Survey.

Conference goal	Evaluation results
Goal 1: Provide an effective, meaningful professional development experience in biology instruction for a diverse group of participants from community college and high school settings.	OTP provided a professional development experience that resulted in participants reporting a more effective overall professional practice, whether teaching or interpreting (80%), as well as feeling better prepared to address the needs of their students (92%) as a result of what they learned at the OTP conference. Teacher quote: "The Deaf-know knowledge made me more resilient and my class more welcoming and empathetic to all my students. I incorporated BioQUEST resources and modules we had learned about in my course design. Providing material and delivery in different ways not only engaged students in active learning but also made my classroom more equitable." Interpreter quote: "Sometimes it is hard to disconnect from the English and show what is happening. I can see a difference in how the interpreting is understood when I make time for that. The student attitude is improved because they are more interested in what is happening in class. They are more engaged."
Goal 2: Explicitly address the role of a UDL approach in building accessible, inclusive, productive learning environments in introductory biology, particularly for deaf/hh students.	Eighty-six percent of respondents agreed that they applied UDL principles more effectively to their teaching as a result of what they learned at the OTP conference. Participant quote: "The Universal design concept taught at the conference expanded my understanding on students' potential. My implementation on equity has improved. I was able to create more resources for ASL-dependent students to have more access to English-based science literacy. For example, student-made presentation slides to include ASL video of themselves summarizing their concept AND to embed caption. This activity allowed students to analyze their ASL and English articulation and for me to assess students' content understanding and support their English skills." Participant quote: "I offered different means of assessment, including discussion board posts, image uploads, and narratives. These made the assessments and assignments more varied and more interesting for all students." Participant quote: "Making case studies accessible in ASL videos and Alt-text empowered my students to check their observations and inferences by using the addition [information] to verify their understanding and lead their discussions."
Goal 3: Demonstrate how to make effective pedagogical practices, specifically case-based learning, inclusive and UDL aligned in an introductory biology context.	Seventy-three percent of respondents reported using case studies in their lessons as a result of what they learned at the conference. Participant quote: "We used the Twins Say What?! video case to start our genetics unit. That sparked lots of conversation and helped students realize that they knew more than they initially thought." Teacher quote: "I set a goal to implement some type of case studies into my classes. I loved this! It was great to see the students excited, intrigued, and motivated to learn answers to questions they had. More exciting for me—they wrote my lesson plans and most always fit into the goals I wanted to achieve anyway. AND sometimes more."
Goal 4: Increase educators' awareness of biology-related technician careers.	Respondents also noted that they used the resources they learned about at the conference (88%) and that these resources were useful (88%). When asked about which resources they had used, the top three sources were the DeafTEC website, BioQUEST, and NTID. Participant quote: "I've used DeafTEC as a reference for the UDL principles and NTID/RIT to assist my students with exploring their programs of study to consider as a college choice." Participant quote: "I incorporate information from InnovATEBIO workshops into my biotech classes, and keep an eye on their FB group for interesting new developments to share with my classes. It's been a great source of info about vaccines and the pandemic. I believe it was through the DeafTEC website that I got some good pointers about employment for deaf graduates as well as useful 'survival signs.'"

REFERENCES

Baker, S., Gersten, R., & Scanlon, D. (2002). Procedural facilitators and cognitive strategies: Tools for unraveling the mysteries of comprehension and the writing process, and for providing meaningful access to the general curriculum. *Learning Disabilities Research & Practice*, *17*(1), 65–77.

Basham, J. D., Gardner, J. E., & Smith, S. J. (2020). Measuring the implementation of UDL in classrooms and schools: Initial field test results. *Remedial and Special Education*, *41*(4), 231–243.

Braun, D. C., Clark, M. D., Marchut, A. E., Solomon, C. M., Majocha, M., Davenport, Z., … & Gormally, C. (2018). Welcoming deaf students into STEM: Recommendations for university science education. *CBE—Life Sciences Education*, *17*(3), es10.

Braun, D. C., Gormally, C., & Clark, M. D. (2017). The Deaf Mentoring Survey: A community cultural wealth framework for measuring mentoring effectiveness with underrepresented students. *CBE—Life Sciences Education*, *16*(1), ar10.

Brownell, S. E., & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and … tensions with professional identity? *CBE—Life Sciences Education*, *11*(4), 339–346.

Campbell, T., & Wescott, J. (2019). *Profile of undergraduate students: Attendance, distance and remedial education, degree program and field of study, demographics, financial aid, financial literacy, employment, and military status: 2015–16*. Washington, DC: National Center for Education Statistics.

Carnevale, A. P., Strohl, J., & Ridley, N. (2017). *Good jobs that pay without a BA: A state-by-state analysis*. Washington, DC: Georgetown University Center on Education and the Workforce. Retrieved November 10, 2021, from https://goodjobsdata.org/wp-content/uploads/Good-Jobs-States.pdf

CAST. (2018). *Universal Design for Learning guidelines, version 2.2*. Retrieved June 3, 2021, from http://udlguidelines.cast.org

Community College Research Center. (2021). *Community College FAQs—What percentage of undergraduates attend community college?* Retrieved June 16, 2021, from https://ccrc.tc.columbia.edu/Community-College-FAQs.html

Connell, B. R., Jones, M. L., Mace, R. L., Mueller, J. L., Mullick, A., Ostroff, E., ... & Vanderheiden, G. (1997). *The principles of Universal Design, version 2.0*. Raleigh, NC: Center for Universal Design, North Carolina State University.

Dawson, P., & Guare, R. (2018). *Executive skills in children and adolescents: A practical guide to assessment and intervention*. New York, NY: Guilford.

Dewsbury, B., & Brame, C. J. (2019). Inclusive teaching. *CBE—Life Sciences Education*, *18*(2), fe2.

Dostal, H., Gabriel, R., & Weir, J. (2017). Supporting the literacy development of students who are deaf/hard of hearing in inclusive classrooms. *The Reading Teacher*, *71*(3), 327–334.

Earley, P. C. (1985). Influence of information choice and task complexity upon goal acceptance, performance and personal goals. *Journal of Applied Psychology*, *70*(3), 481–491.

Eddy, S. L., & Hogan, K. A. (2014). Getting under the hood: How and for whom does increasing course structure work? *CBE—Life Sciences Education*, *13*(3), 453–468.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences USA*, *111*(23), 8410–8415.

Fuchs, L., Butterworth, J., & Fuchs, D. (1989). Effects of ongoing curriculum-based measurement on student awareness of goals and progress. *Education and Treatment of Children*, *12*(1), 63–72.

Funk, C., & Parker, K. (2018). Diversity in the STEM workforce varies widely across jobs. *Women and Men in STEM Often at Odds over Workplace Equity at Pew Research Center, January 2018*. Retrieved April 1, 2022, from https://www.pewresearch.org/social-trends/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/

Gernsbacher, M. A. (2015). Video captions benefit everyone. *Policy Insights from the Behavioral and Brain Sciences*, *2*(1), 195–202.

Gibson, P., & Mourad, T. (2018). The growing importance of data literacy in life science education. *American Journal of Botany*, *105*(12), 1953–1956.

Hauser, P. C., & Hauser, A. (2008). The deaf professional-designated interpreter model. In Hauser, P. C., Finch, K., & Hauser, A. (Eds.), *Deaf professionals and designated interpreters: A new paradigm* (pp. 3–21). Washington, DC: Gallaudet University Press.

Helikar, T., Cutucache, C. E., Dahlquist, L. M., Herek, T. A., Larson, J. J., & Rogers, J. A. (2015). Integrating interactive computational modeling in biology curricula. *PLoS Computational Biology*, *11*(3), e1004131.

Herreid, C. F. (1994). Case studies in science—a novel method of science education. *Journal of College Science Teaching*, *23*, 221–221.

Herreid, C. F., Schiller, N. A., Herreid, K. F., & Wright, C. (2011). In case you are interested: Results of a survey of case study teachers. *Journal of College Science Teaching*, *40*(4), 76.

Horowitz, S. H., Rawe, J., & Whittaker, M. C. (2017). *The state of learning disabilities: Understanding the 1 in 5*. New York: National Center for Learning Disabilities.

Humphries, T. (2013). Schooling in American Sign Language: A paradigm shift from a deficit model to a bilingual model in deaf education. *Berkeley Review of Education*, *4*(1), 7–33.

Internet Scout Research Group and American Association of Community Colleges. (2018). *ATE Central*. Retrieved November 4, 2021, from https://atecentral.net/downloads/10518/ATE_Impacts_2018-2019.pdf

Lieu, R., Wong, A., Asefirad, A., & Shaffer, J. F. (2017). Improving exam performance in introductory biology through the use of preclass reading guides. *CBE—Life Sciences Education*, *16*(3), ar46.

Ma, J., & Baum, S. (2016). Trends in community colleges: Enrollment, prices, student debt, and completion. *College Board Research Brief*, *4*, 1–23.

MacFarlane, K. (2018). Higher education learner identity for successful student transitions. *Higher Education Research & Development*, *37*(6), 1201–1215.

Marschark, M., & Wauters, L. (2008). Language comprehension and learning by deaf students. In Marschark, M., & Hauser, P. C. (Eds.), *Deaf cognition: Foundations and outcomes* (pp. 309–350). New York, NY: Oxford University Press.

Meyer, A., Rose, D. H., & Gordon, D. T. (2014). *Universal Design for Learning: Theory and practice*. Wakefield, MA: CAST Professional Publishing.

Nagle, K., Newman, L. A., Shaver, D. M., & Marschark, M. (2016). College and career readiness: Course taking of deaf and hard of hearing secondary school students. *American Annals of the Deaf*, *160*(5), 467–482.

National Academies of Sciences, Engineering, and Medicine (NASEM). (2017). *Building America's skilled technical workforce*. Washington, DC: National Academies Press.

NASEM . (2018). *How people learn II: Learners, contexts, and cultures*. Washington, DC: National Academies Press.

Novak, K., & Rodriguez, K. (2018). *UDL progression rubric*. Retrieved June 2, 2021, from http://castpublishing.org/wp-content/uploads/2018/02/UDL_Progression_Rubric_FINAL_Web_REV1.pdf

NRICH. (2019). *Low threshold high ceiling: An introduction*. Retrieved June 14, 2021, from https://nrich.maths.org/10345

Office of Special Education and Rehabilitative Services. (2021). 42nd Annual report to Congress on the implementation of the *Individuals* with *Disabilities Education Act*, 2020. Washington, DC:

Oliver, M. (1983). *Social work with disabled people*. Basingstoke, UK: Macmillan.

Oliver, M., & Barnes, C. (2010). Disability studies, disabled people and the struggle for inclusion. *British Journal of Sociology of Education*, *31*(5), 547–560.

Polanyi, M. (1962). *Personal knowledge: Towards a post-critical philosophy*. London: Routledge and Kegan Paul.

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Retrieved July 8, 2021, from https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

Pyrko, I., Dörfler, V., & Eden, C. (2017). Thinking together: What makes communities of practice work? *Human Relations*, *70*(4), 389–409.

Rehabilitation Act of 1973. (1973). 29 USC § 701 et seq. Retrieved June 3, 2021, from www.fcc.gov/general/section-508-rehabilitation-act

Rose, D. H., Harbour, W. S., Johnston, C. S., Daley, S. G., & Abarbanell, L. (2006). Universal design for learning in postsecondary education: Reflections on principles and their application. *Journal of Postsecondary Education and Disability*, *19*(2), 135–151.

Rose, T. (2016). *The end of average: How to succeed in a world that values sameness*. San Francisco, CA: Harper One.

Round, J. E., & Campbell, A. M. (2013). Figure facts: Encouraging undergraduates to take a data-centered approach to reading primary literature. *CBE—Life Sciences Education*, *12*(1), 39–46.

Seymour, E., & Hunter, A. B. (2019). *Talking about leaving revisited: Persistence, relocation, and loss in undergraduate STEM education*. Cham, Switzerland: Springer.

Shaewitz, D., & Crandall, J. R. (2020). Higher education's challenge: Disability inclusion on campus. *Higher Education Today*. Retrieved February 4, 2022, from www.higheredtoday.org/2020/10/19/higher-educations-challenge-disability-inclusion-campus

Skomsvold, P. (2014). *Profile of* undergraduate students: *2011–12. Web Tables* (NCES 2015-167). Washington, DC: National Center for Education Statistics.

Smith, B. L., Stumpff, L. M., & Cole, R. (2012). Engaging Students from Underrepresented Populations: The enduring legacies Native cases initiative. *Journal of College Science Teaching*, *41*(4), 64–72.

Solomon, C. M., Braun, D. C., Kushalnagar, R., Ladner, R. F., Lundberg, D., Painter, R., & Nuzzo, R. (2012). *Workshop for emerging deaf and hard of hearing scientists: A white paper*. Washington, DC.

Stanley, E. D., & Waterman, M. A. (2000). LifeLines online-curriculum and teaching strategies for adult learners. *Journal of College Science Teaching*, *29*(5), 306–314.

Thistlethwaite, J. E., Davies, D., Ekeocha, S., Kidd, J. M., MacDougall, C., Matthews, P., ... & Clay, D. (2012). The effectiveness of case-based

learning in health professional education. A BEME systematic review: BEME Guide No. 23. *Medical teacher*, *34*(6), e421–e444.

Tobin, T. J., & Behling, K. T. (2018). *Reach everyone, teach everyone: Universal Design for Learning in higher education*. Morgantown, WV: West Virginia University Press.

U.S. Bureau of Labor Statistics. (2021, September 8). *Occupational outlook handbook*. Retrieved November 10, 2021, from www.bls.gov/ooh/life-physical-and-social-science/home.htm

U.S. Equal Employment Opportunity Commission. (2016). *Diversity in high tech: Executive summary*. Retrieved November 9, 2021, from www.eeoc.gov/special-report/diversity-high-tech

Waterman, M., & Stanley, E. (2008). *Biological inquiry: A workbook of investigative case studies* (2nd ed.). San Francisco, CA: Benjamin Cummings.

Wright, A. M., Schwartz, R. S., Oaks, J. R., Newman, C. E., & Flanagan, S. P. (2019). The why, when, and how of computing in biology classrooms. *F1000Research*, *8*, 1854.

Yager, R. E. (1983). The importance of terminology in teaching K-12 science. *Journal of Research in Science Teaching*, *20*(6), 577–588.

Zehender, C., Metzker, J., Kleine, K., & Alby, C. (2021). *Learning that matters: A field guide to course design for transformative education*. Gorham, ME: Meyers Education Press. ISBN 978-1-9755-0451-9