A magazine for mathematics
and science educators

TERC

FALL 2022

1 EMPower: Offering Tools to Adult Education Teachers

CONTENTS

Letter from the President

I am excited to present the Fall 2022 issue of *Hands On!* These articles will capture your attention, highlighting TERC staff's passion and commitment for providing high quality teaching materials and learning experiences to all learners.

In **EMPower: Offering Tools to Adult Education Teachers**, the Director of the Adult Numeracy Center at TERC's journey explains how her career and teaching skills were transformed by the program that she is now aptly leading through an expansion to online and LMS.

The Construction of Silence in a Parent Support Group: Tracing the Invisible Fabric shares research data gathered via observations in several eastern New England interest groups. Each community has its own body of knowledge, practices, and discourse which was reflected in responses to questions such as what science is important and how is it discussed.

Developing the materials and teaching strategies for sign language interpreters **Increasing Student Interpreters' Ability to Accurately and Fluently Interpret STEM Content** will expand the pool of interpreters who can sign STEM vocabulary for deaf or hard of hearing (DHH) students. This is an essential step toward increasing the representation of DHH students pursuing and succeeding in science careers.

More Than Who's at the Table: Co-Designing a STEM-Based Virtual Reality Game with Neurodivergent Learners is a thought-provoking piece about what true representation and 'a seat at the table' looks like during a VR game co-design process. Learn what strategies were developed to ensure that the stakeholders were indeed co-designers.

I want to take a moment to thank Dr. Martin Storksdieck for his board service to TERC. He has been a TERC Trustee since 2014 and Board Chair since 2016. Martin always brought enthusiasm, vast experience, expertise, and great ideas to this role, building on his keen understanding of TERC's work and respect for employees' steadfast dedication to our mission. He has been a valued, strategic thought partner as we confronted challenges or considered opportunities. Martin's sense of humor, competence, and confidence, balanced with his playful manner, will be missed. I certainly will not lose his phone number and he will always be a member of the TERC family.

Laurie

Laurie Brennan, President

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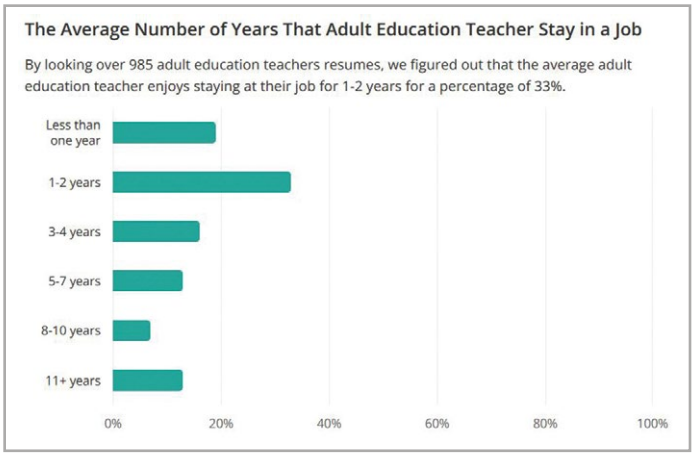
EMPower

OFFERING TOOLS TO ADULT EDUCATION TEACHERS

BY HEIDI SCHULER-JONES

WHEN I BEGAN TEACHING IN ADULT EDUCATION IN GEORGIA IN 2006, I was given multiple classes spread across three counties and three different programs. None were leveled by assessment scores, so students reading on a third-grade level were mixed with students reading at a ninth-grade level. I was told I would be teaching all five subjects on the GED: Reading, Writing, Math, Science, and Social Studies. My new boss pointed to a wall of thrift store bookcases weighed heavily with aging, mismatched booklets and told me I could use those for my lessons, but that most materials would have to be shared because there weren't enough copies to go around. She left the room with a smile of deep gratitude that I'd accepted this part-time teaching job.

That was my introduction to the world of teaching in adult education. Unfortunately, things have not changed all that much since then. The uncertainty and lack of structure in instructional materials and classes, inadequate working conditions, lack of professional development and proper training, and minimal administrator and/or collegial support (Smith & Hofer, 2003) led to many new teachers leaving after two years or less (Adult Education Teacher Demographics and Statistics in the US, 2022.)

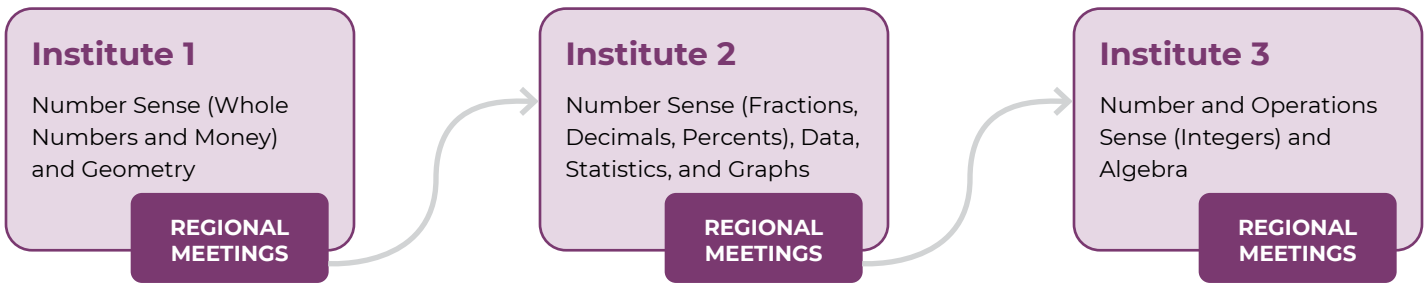


To be honest, I didn't expect to stay long myself. That all changed in 2010 when I was invited to participate in the pilot of the Adult Numeracy Instruction — Professional Development training (ANI-PD). It was during this intensive series of three two-day institutes that I was finally given the right tools, instructional routines, and training to do more for my math students than I ever imagined possible.

Prior to ANI-PD, I'd considered myself a decent math teacher, but I soon realized I could be doing so much more, especially around teaching math conceptually, i.e., explaining the *why* and not just the *how* behind the math. The best part of ANI-PD was that I not only learned how to teach math with a focus on conceptual understanding, but I finally had instructional materials that were designed to teach adults that way. That was my first exposure to the *Extending Mathematical Power (EMPower™)* book series. I'm still promoting its use more than a decade later.

To say the *EMPower* books and the ANI-PD transformed my teaching is an understatement. Those experiences shaped my approach to education as a whole and modeled for me the importance of teachers having access to background knowledge and support on guiding students through collaborative learning where the teacher probes for deeper understanding through questions rather than quick solutions. I learned that traditional lecture and drill instruction limited the opportunity for adult learners to apply the collective wisdom they brought to the learning space from their years of experience as workers, consumers, and parents. I learned the teacher was better placed as a guide, armed with the kinds of tools and training that made her feel confident enough to explore math and not just teach procedures the way they had been taught for generations.

Years later, I am now the director of the Adult Numeracy Center (ANC) at TERC, the birthplace of the *EMPower* book series and of ANI-PD (originally called Teachers Investigating Adult Numeracy—TIAN). Never did I imagine being in a position to explore ways to enhance the impact of the *EMPower* series for other adult educators, yet here I am, proud to carry forward the vision of bringing the series to other teachers in a new digital format.



The Adult Numeracy Instruction Professional Development (ANI-PD) model included a series of three, two-day Institutes, spaced with time in between for teachers to practice their new understandings and reflect with colleagues..

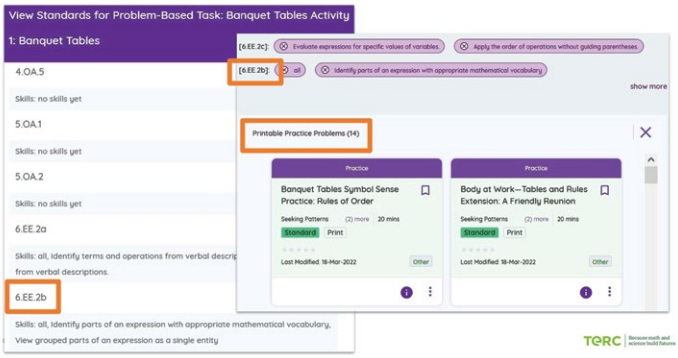
Expanding *EMPower's* Reach

With TERC's distribution contract expiring in April 2021, we determined the series could best be served by identifying a new distributor, potentially one with a digital platform to increase accessibility for adult learners. While meeting with potential distributors early in 2021, we also surveyed the adult education field, including current *EMPower* users, about what they would like to see improved to make the books more user-friendly and a better fit for their program's needs. Due to the overwhelming shift towards remote instruction with the advent of the COVID-19 pandemic, many respondents expressed the desire for online materials. However, programs were concerned that *EMPower's* heavy reliance on manipulatives and collaborative learning made it impossible to use with remote instruction. Teachers working in corrections settings also noted the difficulty of using manipulatives due to security concerns. It was clear that while many longed to go back to face-to-face instruction, the reality was that remote learning was here to stay. *EMPower* didn't seem to fit in that kind of instructional setting.

Given this feedback, we narrowed our search for a distributor who could help us expand *EMPower*'s reach to those teaching remotely and those in need of options beyond printed books and physical manipulatives. In Walch Education, TERC found a partner that not only could handle printing and distribution of the books, but that also had a learning management system (LMS) that could make an online *EMPower* experience a reality. The LMS, called *Curriculum Engine (CE)*, would allow teachers to assign *EMPower* lessons, activities, practice, and assessments to students electronically, using CE or other common LMS platforms.

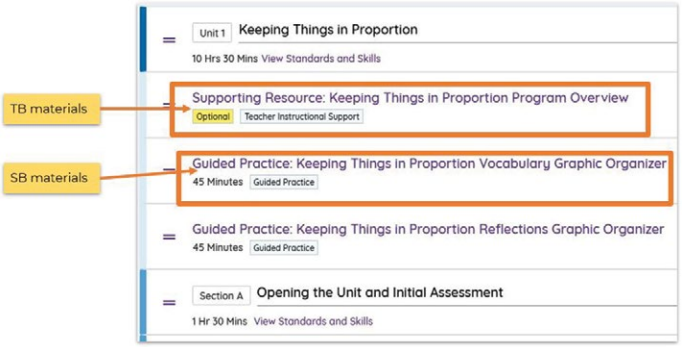
How Curriculum Engine *EMPowers* Teachers

- All seven titles are now fully-aligned to the *College and Career Readiness Standards for Adult Education (CCRSAE)* and the eight Mathematical Practices. Every activity, practice page, and test practice is aligned with these.
- All content is now searchable by the CCRSAE, Math Practices, key words, learning type (application, procedural, conceptual), and type of resource (guided activity, practice, assessment).



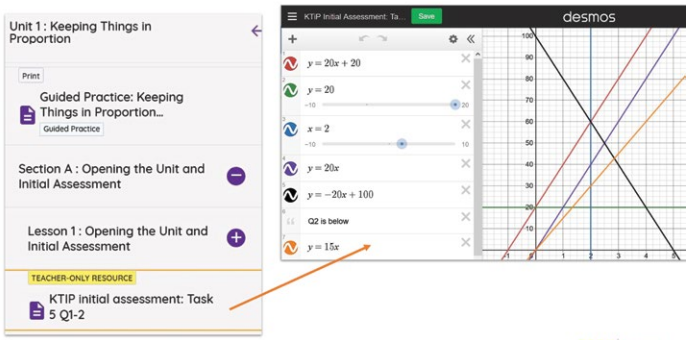
Teachers now have the ability to search *EMPower* for content that aligns with specific College and Career Readiness Standards for Adult Education and type of resource (guided activity, practice, assessment).

- All Teacher Book (TB) resources for a lesson are now in one place, i.e., all Blackline Masters are attached to the end of the teacher material for that lesson and followed by the Answer Key for the activities in that lesson.
- Student Book (SB) pages are organized directly after the TB resources and can be rearranged into a custom order, including selecting resources that work best for a class, such as Graphic Organizers.



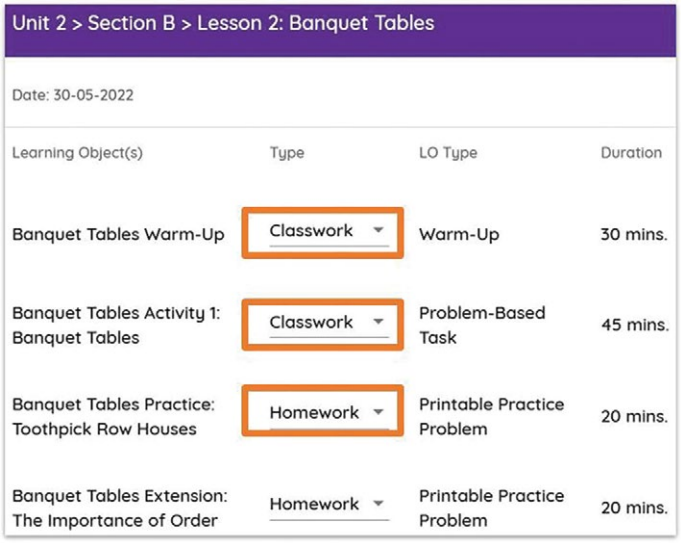
All of the necessary teacher and student materials for an instructional unit are organized in one place.

- Teachers can combine activities and practice pages from each *EMPower* title they have licensed to create a new *EMPower* course.
- Teachers can add external sources to their *EMPower* courses, such as OERs like Desmos, virtual manipulatives, or teacher-created content.



Curriculum Engine allows teachers to incorporate OER resources (such as Desmos, featured here) into *EMPower* lessons.

- Teachers can assign start/end dates or specific days of the week for instruction and choose which activities/practice will be done in class and which will be assigned for homework. All of this is tracked on the teacher schedule in the system.



Curriculum Engine allows teachers to designate activities/practice as in-class work or homework.

- *EMPower* courses set up in CE can be exported to a different LMS (including Google Classroom and Canvas) through a Common Cartridge Export feature built into the Course Management Options.

Supporting Teachers

During our earliest CE conversations with Walch, we realized there were some important caveats and considerations we needed to address regarding how much flexibility we wanted to allow in digital books, especially for teachers who were new to teaching math conceptually and might not have access to high-quality PD on math instruction beyond teaching procedures. For example, we knew teachers were excited by the prospect of being able to organize their own digital version of an *EMPower* "book" with the lessons they teach from various books all in one place. We knew they were interested in organizing the books or specific lessons based on course length, student levels, or specific math content and then loading them into their program's LMS. However, we also recognized potential pitfalls of giving teachers too much flexibility in pulling apart cohesive lessons aligned to a set of objectives that touched on multiple math topics at the same time. For example, what if teachers only used the practice pages without comprehending and addressing the math concept discovered in the lesson activities? Likewise, what if teachers only viewed the instructional support for an activity without seeing the connection of the activity to the opening and closing student discussions? In the print version, teachers are exposed to *all* the teacher and student materials owing to the simple fact that the book components are bound together. In a digital version with no restrictions on customization, they might only see the specific pages they selected and potentially miss important concepts and instructional suggestions.

Ultimately, we identified the guardrails we wanted in place to encourage teachers to review the complete lesson, not just certain activities, so they could benefit from understanding the coherence between content and math concepts as they related to all the objectives in a lesson. Walch helped us navigate a balance between meeting the digital needs of instructors while minimizing the pitfalls of allowing too much flexibility when picking and choosing lessons, activities, practice, and assessment.

All the amazing features now available in CE only add to the many supports *EMPower* always has provided to teachers. What I needed most as a new adult education teacher were cohesive math lessons and engaging math activities that could ultimately become the math curriculum I needed. The *EMPower* books provided me those things as well as math background, helpful hints, suggested questions, anticipated student responses, sample student work, and a teacher

summary. All these supports, coupled with the in-depth ANI-PD training on teaching math conceptually, allowed me to deepen my understanding of math and helped me to enjoy teaching more because the students also saw their math interests and abilities deepen and their confidence soar.

LEARN MORE

Are you interested in what *EMPower* has to offer you and your students? Download FREE sample lessons from each of the seven titles in the series and hear some student and teacher video testimonials at https://www.walch.com/terc-empower. Visit our FAQ page at https://www.terc.edu/empower/faqs/ for answers to common questions such as which title to use for a specific math level or content need, or how to use *EMPower* in multilevel classrooms or with students with inconsistent attendance.

To learn more about *EMPower* Professional Development, contact us at https://www.terc.edu/empower/professional-development/ or email empower@terc.edu.

ACKNOWLEDGEMENTS

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The original TIAN project was co-developed by TERC and the Center for Literacy Studies at the University of Tennessee and was funded by the National Science Foundation. The materials herein are based on work funded by the National Science Foundation under Grant No. NSF_ESI-0455610.

AUTHOR

Heidi Schuler-Jones is the Director of the Adult Numeracy Center at TERC. She has worked in adult education since 2006, spending much of that time expanding her understanding of tools and instructional strategies that make math meaningful, accessible, and fun for adult learners. She manages the SABES Mathematics and Adult Numeracy Curriculum & Instruction PD Center, oversees updates, research, and teacher support for the *EMPower* math series, and continues to facilitate professional development such as the *Adults Reaching Algebra Readiness* $(AR)^2$ institutes. At SABES, she was the lead developer of the *Curriculum for Adults Learning Math* (CALM). She is the president of the Adult Numeracy Network.

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RESOURCES

Adult Numeracy Center (ANC) at TERC
https://www.terc.edu/adultnumeracycenter/

Adult Numeracy Instruction – Professional Development training (ANI-PD) https://lincs.ed.gov/publications/pdf/LINCS_ANI_flyer.pdf

Adult Numeracy Network (ANN)
https://www.adultnumeracynetwork.org/

Curriculum for Adults Learning Math (CALM)
https://www.terc.edu/calm/about-calm/

College and Career Readiness Standards for Adult Education (CCRSAE)
https://lincs.ed.gov/professional-development/resource-collections/profile-521

Teachers Investigating Adult Numeracy (TIAN)
https://www.terc.edu/tian/

Walch Education to purchase curriculum
https://www.walch.com/terc-empower/

Walch Curriculum Engine (CE)
https://www.walch.com/curriculum-engine/

The Construction of Silence in a Parent Support Group

Tracing the Invisible Fabric

BY BRIAN DRAYTON

In a project I call "Tracing the invisible fabric of science in everyday life," I have been investigating "vernacular science" in several interest groups in eastern New England. My research is based on the idea that an understanding of science learning in our society must take account of the processes by which science is understood, constructed, and used in everyday settings—the 'vernacular' culture of science (Wagner, 2007).

Vernacular science is constructed through conversation, and is situated in specific arenas of action, communities of interest (Fischer, 2001) or of practice (Lave and Wenger, 1991)—such as garden clubs, hunting associations, parent groups, and so on. Each community has its own body of knowledge, its own practices and discourse, and its own methods of self-propagation within and across age cohorts. So vernacular science, like any other kind of knowing, is a social achievement, and it is one part of how a person enacts their identity and plays their role within the multiple cultures they participate in (Holland and Lave, 2009).

Since the onset of the COVID pandemic, there has been continuing controversy about the safety and efficacy of vaccines (among other science-related disputes). This has been infuriating for some people who place confidence in medical science and public health, but it should not have been a surprise. In this article, I tell a story drawn from field data collected in 2018–19, before any of us had heard of COVID. It is a story about how people see "good science" through a lens, not of ignorance or of prejudice, but of alternative accounts of how the world works.

Brian Drayton, a plant ecologist, has been at TERC since 1986, working as a curriculum developer, educational researcher, and teacher educator. He is co-director, with Joni Falk, of the Center for School Reform at TERC.

https://www.terc.edu/profiles/brian-drayton/

Setting for this study

I have been making ethnographic observations in several community settings, asking what science is important to the group, how it gets discussed, and how—and from whom—people learn their science. (It isn't always called "science," though; see Drayton, 2018). In 2018–19 I happened to be participating in a parent group in a school (it will be called The School in this article), which grows out of a world-wide philosophical movement originating in the early 1920s (I will refer to this as The Movement).

I had joined the group after speaking about it with a "gatekeeper," one of the parents who had gathered the group, to make sure that I would not be a disruptive presence. I sat in the meetings, taking field notes either during the meeting or (more often) sitting in my car directly afterwards. I also conducted a few interviews to dig deeper on various subjects that came up.

At this time, several outbreaks of measles and whooping cough had occurred on the West and East Coasts in communities where vaccine resistance or hesitation was common (Dubé et al., 2021). Mostly these clusters were associated with communities committed to one or another counter-cultural approach to education, including some schools in The Movement. Because of these outbreaks, vaccination was a live issue in private conversations or in the parking lot outside The School, and in the community at large—except in the parent group meetings, where the topic never came up. What was going on?

Three Orientations, Three Sources of Authority

It became evident that there were three main points of view on the question of the vaccines for childhood diseases.

[1] Philosophical Parents

There were "philosophical" parents, who had come to The School because of the educational philosophy that underlies it. Within that philosophical stream, there are elaborated alternative views of education, personality development across the life-cycle, agriculture, and medicine, each with a decades-long history of research and practice, training and accreditation programs, and academic and popular books, websites, social media, and periodicals. The medical authorities of The Movement have asserted that vaccination is a useful medical procedure. Nevertheless, some in The Movement are vaccine-averse, owing to possible negative effects on the body's systemic health and robustness to disease in general and an alternative account of the body-mind relationship that draws on some aspects of herbal and other "naturopathic" medicine. For this reason, these people preferentially seek alternative methods for protection against infection. Some teachers inclined to this latter view; some parents did, as well, from their own study of the philosophy behind The Movement. The knowledge that respected authorities advocate this view and can articulate the theory behind it in some depth, provided reassurance and support for those in this group. The "philosophical" group takes its lead from experienced, usually older, practitioners of the Movement's philosophy. The philosophy gave them a rich explanatory framework within which decisions about vaccination were situated.

[2] New Age Parents

Another group of parents, which might be characterized as "New Age," were attracted by The School's "whole child" pedagogy. Many subscribed to ideas from the "holistic parenting" movement widespread in Europe and North America, placing a high value on experiences in nature, on storytelling, the arts, and community life, "natural" foods and medicines, and less emphasis on conventional success and academic achievement. The parents in this group were not particularly well-informed about the principles on which The School is founded, but assumed that their own worldview is in harmony with that of The Movement. The "New Age" parents' attitudes towards vaccination were negative, often in absolutist terms, shunning all vaccines for any childhood diseases.

The "New Age" movement is eclectic and wildly diverse and the "New Age" parents offered various reasons for their position, ranging from fears about possible negative side-effects of vaccines, to a general alternative view that much disease is the result of environmental factors such as air or water pollution, stress, or pesticide residues in foods. Their authorities for their position included a range of "health influencers" on the Internet, as well as trusted figures in the local community. There are elders in this community as well—in this case, parents who have been active in the holistic parenting movement, or otherwise worked to develop an elaborated theoretical account of health and wholeness, both for their children and for themselves.

> *Several of our parents were leaders in the holistic parenting organization, and this was years ago … . The holistic mom's network was very anti-vax. Lots of chiropractors, people who really want minimal intervention on the body and all this natural healing, et cetera. That influence is still in the school community.*

[3] Mainstream Parents

A third group of parents followed the guidance of mainstream medicine, vaccinating their children as recommended, and making use of "allopathic" medicines as prescribed by their doctors. While some of these parents were also concerned about health effects of pollution, pesticides, and so forth, and often adopted some "holistic health" practices, it appeared that their main source of authority for their actions about vaccines was their physician, supplemented by media or other sources. Such parents might or might not have had a coherent explanatory account of how and why vaccines "work," but the whole of mainstream science and medicine served as a basis for their decisions. The "mainstream" group appealed to popular accounts of science and medicine, and consulted their physicians for immunizations. In a sense, they could take for granted the established findings of mainstream science and medicine—without necessarily understanding them in depth.

To summarize: Each of these groups was well-represented in the parent body. Each of them appealed to some authority to support their position, relating it to more general theories about human nature and mainstream science. Consequently, when a new scientific or health topic came up, they had a framework within which to interpret and evaluate the new idea or practice.

The Construction of Silence, and the Role of Common Ground

Robust discussions of child-rearing practices, the economy, and a wide range of other subjects were common in the community, so it was surprising that vaccination did not come up in the parent group. One parent told me that in less public settings,

> *... when it comes up, it seems like the two people who are on the polar opposite ends of the spectrum speak out. And then other people just kind of don't say much.*

Vaccination was not the only topic in which deep and well-supported convictions resulted in public silence. Was it merely avoidance of conflict that resulted in a kind of self-censorship? Perhaps in some cases, but my observations and interviews suggest that parental sense-making and decision-making as part of The School's community were influenced also by a commitment to "common ground"—in this case the commitment to a particular experience for their children. This seemed to set or calibrate the priorities by which parents chose to speak or to be silent on deeply controversial issues. When the COVID crisis came to town in 2020, the three communities I have described were prepared, and each reacted in accordance with their own framing of science, the science of their "heart communities."

Reflections

Science educators are becoming more aware and respectful of the "funds of knowledge" (Calabrese-Barton and Tan, 2009) that children bring to schooling from their home and community life. Very often, this awareness is seen primarily as an alternate approach to teaching mainstream science content. The funds of knowledge provide new resources for science learning, and a way to teach science in a way that is more inclusive of cultural diversity. However, children and their parents in the same community may also inhabit cultures that *resist* mainstream science—about climate change, about evolution, about a public health issue—on the basis of an alternative account of the way the world works.

Vernacular science is embedded in (and serviceable for) local communities of interest, and is part of how people engage in "the process of authority" (Dewey, 2008). Its relationship to mainstream science can be conflictual, confounding, or complementary/synergistic. A student—or any other human—who works within such a vernacular account of the world is paying attention to values and trusted sources of authority that are part of their meaning-making. They don't live in a "private universe" but a rich, dynamic, and complex world, shared with friends, family, and community, who also share frames for interpreting new ideas and information—whether from the media or the school room.

Yet we all belong to more than one community and at times become aware—sometimes painfully—that our colleagues or neighbors do not share the same values or respect the same authorities. In order to cope, we can try to "translate" ideas from one mental world to another. Or we can just be silent, a phenomenon that has long been familiar to anthropologists (Norgaard, 2011; Zerubavel, 2006). The silence in each community gets its meanings from differing motivations—such as fear of censure, a desire for comity, or a shared commitment to an acknowledged common good.

In this case, the education of their children according to a specific pedagogy served as a common ground upon which to establish relationship and mutual understanding (Clark, 1996). Finding this common ground also resulted in the construction of silence about certain topics, and whether the silence can be broken will depend on how the common ground can be reconstructed to support dialogue among deeply held worldviews. The challenging, uncertain nature of such conversations can itself make people reluctant to break the silence. My research suggests that such community dynamics deserve further research, because they are an important part of what we call "science education."

Earlier research on this project can be found in *Hands On!* Spring 2018, 'Tracing The Invisible Fabric of Everyday Science: Field Notes,' found at https://www.terc.edu/hands-on-magazine-spring-2018/

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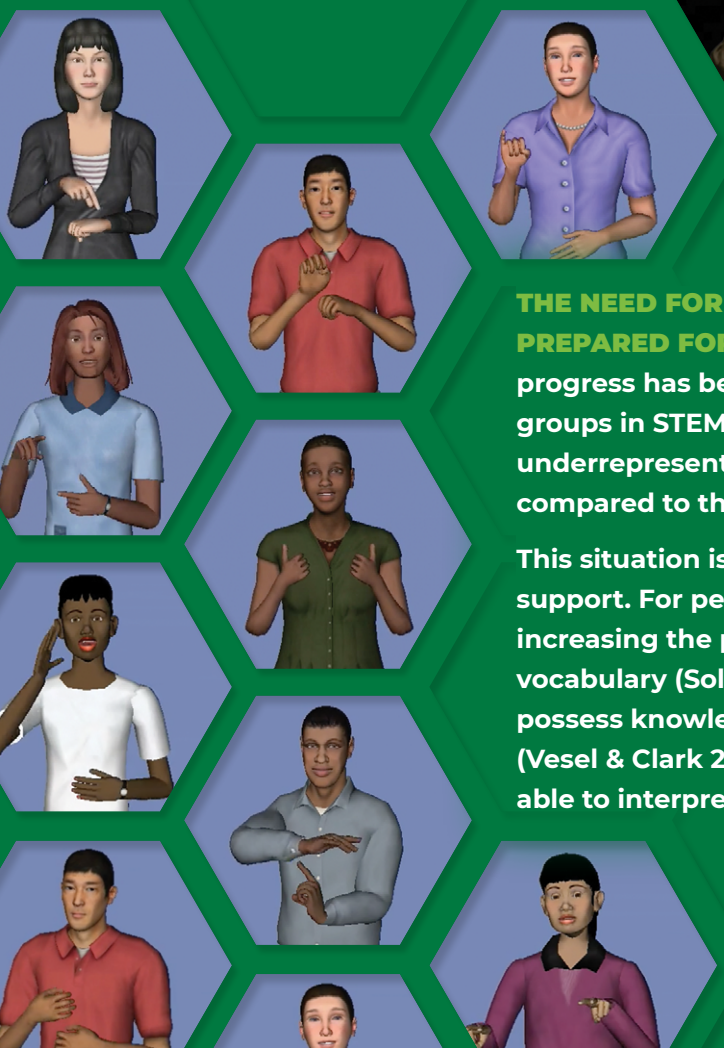
INCREASING STUDENT INTERPRETERS' ABILITY TO ACCURATELY AND FLUENTLY INTERPRET STEM CONTENT

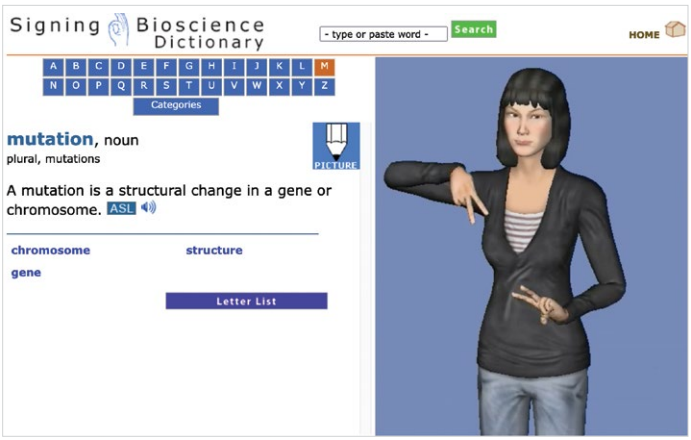
BY JUDY VESEL, M. DIANE CLARK, ASHLEY GREENE, AND TARA ROBILLARD



THE NEED FOR A DIVERSE TALENT POOL OF STEM-LITERATE AMERICANS PREPARED FOR THE JOBS OF THE FUTURE IS UNDENIABLE. While progress has been made in broadening participation of underrepresented groups in STEM, data show that persons with disabilities remain underrepresented in science and engineering education and employment compared to their representation in the U.S. population (NCSES 2019).

This situation is often due to limited access to accommodations and support. For persons who are deaf or hard of hearing, this requires increasing the pool of interpreters who have knowledge of signed STEM vocabulary (Solomon et al. 2013; Grooms 2015, Lang et al. 2007), who also possess knowledge of the STEM content they will be called on to interpret (Vesel & Clark 2019; Gormally 2017; Kurz, Schick, & Hauser 2015), and will be able to interpret it fluently and accurately.

To address this need, TERC and Lamar University researched and developed a unique set of teaching and learning materials designed to provide student interpreters enrolled in Lamar's four-year undergraduate interpreter training program with the knowledge and skills required to support students who are deaf or hard of hearing in successful learning of life science content. The immediate precursor for this work is a collaboration between the partners (NSF Award #1703343) that resulted in a prototype Signing Bioscience Dictionary (SBD) and new knowledge about what interpreters need to know and be able to do to fluently interpret STEM content (Vesel, Clark, & Robillard 2020).



An SBD Term Page

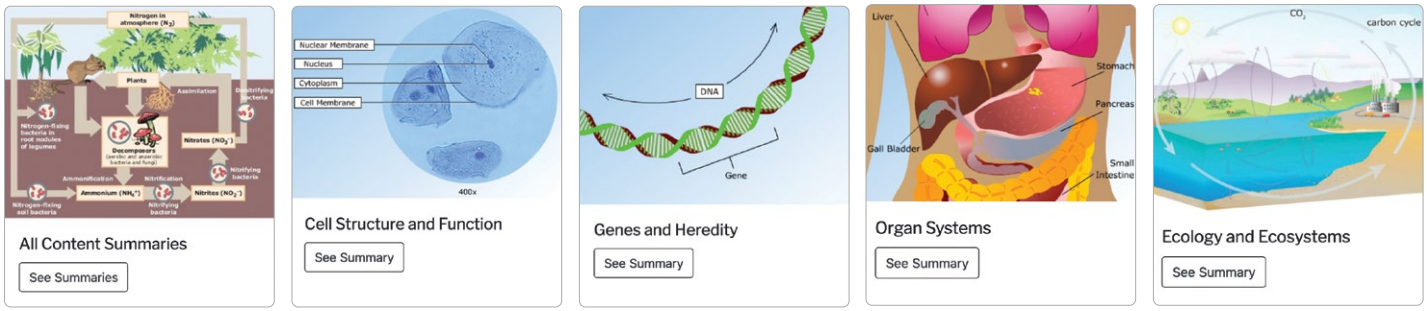
WHAT TEACHING AND LEARNING MATERIALS WERE DEVELOPED?

SIGNING BIOSCIENCE DICTIONARY

Development of a beta version of the SBD involved review of the terms in the prototype SBD; identification of terms in the prototype that required adjustment to increase the contrast between the color of the avatar's clothing and the character's hands to make the hand motion easier to see during signing; and pinpointing terms within definitions that require understanding to comprehend their meaning. Terms within definitions were then incorporated into the term page interface and hyperlinked to their respective SBD pages. The navigation bar interface was also modified so that users could use the Back icon or Previous Word button to return to the original terms and definitions. Integration of these modifications allow users to navigate directly to terms within definitions and back to original terms without having to go to the alphabetical Letter List to find them. The resulting beta SBD includes 1580 primary terms. Of these, 1524 have terms below their definitions for a total of 7099 links beneath definitions. The beta version of the SBD is available from https://signsci.terc.edu/video/SBD/interpreters/ and https://signsci.terc.edu/video/SBD.htm.

LIFE SCIENCE CONTENT SUMMARIES

Development of summaries of key life science content needed for fluent and accurate interpretation of undergraduate biology lecture material involved identifying life science content topics that emerged from review of the definitions and terms included in the content categories incorporated into the prototype SBD interface. To ensure accuracy of the material, we used the most recent edition of Campbell Biology, the text used for Lamar's introductory undergraduate biology course, and material and images that the TERC team had researched and developed for another award and that had been reviewed by content experts. Prior to being finalized, draft versions of the summaries were reviewed by content experts at Lamar for accuracy and relevance to the undergraduate biology courses taught at Lamar. The summaries are available from https://signsci.terc.edu/video/SBD/interpreters/ and https://signsci.terc.edu/video/SBD/interpreters/content-summaries.html.



Links on the Life Science Content Summaries webpage

Fingerspelling Principles Explained Page

Fingerspelling Principles Review Page

FINGERSPELLING VIDEOS

Producing videos explaining the principles of fingerspelling and the application of these principles to STEM vocabulary encountered in undergraduate biology lecture involved Lamar team members who are native signers conducting an analysis of their implicit fingerspelling rules. This proved challenging and resulted in use of the strategies for teaching effective fingerspelling presented in James V. Van Manen's book, *The Fingerspelling Code: Linguistics of the ASL Alphabet* (2018), as the primary resource for development. The two resulting videos explain the principles of fingerspelling and provide a review of these principles using examples and accompanying explanation. Both videos explain how to use the phonology of ASL to capture syllabification in signing and demonstrate how to include syllabification rather than citation format in fingerspelling. Syllabification for spoken languages divides words into syllables and influences their pronunciation. In a similar way, for ASL prior handshapes influence the phonology of handshapes that follow. This type of research is rare if found at all in sign language linguistics. An additional component of development included integration of elements of universal design into the interface. Once selected, users can view the video in sign with or without captions or listen to it in English with or without simultaneous sign or voice overlay. They can also exercise the option to increase or decrease text size, loudness, and contrast, and play and replay all or part of the video as often as needed. The videos and accompanying transcripts are available from https://signsci.terc.edu/video/SBD/interpreters/index.html and https://signsci.terc.edu/video/SBD/interpreters/fsprinciples-explained.html; https://signsci.terc.edu/video/SBD/interpreters/fsprinciples-review.html.

WHAT DOES OUR RESEARCH SHOW?

Evaluation of the materials involved a two-phase study that focused on Genes and Heredity. This category was selected because many of the terms included in it must be fingerspelled. The Lamar team had primary responsibility for all aspects of instruction associated with both parts and for data collection. Responsibilities for data preparation and analysis were shared among TERC and Lamar.

During Phase I, students focused on studying and mastering the genetics vocabulary included in the SBD and related content. During Phase II, they focused on learning and becoming able to use syllabification in signed fingerspelling. The Lamar team mentored and guided participants during both phases. A video narrative of a genetics lecture produced in spoken language provided the measure used to determine the effectiveness and accuracy of participants' interpreting ability using a pre- and post-design. The presentation was interpreted at the beginning and end of the first phase. This same video was used weekly to monitor fluency of interpretation during the second phase.

To recruit participants, flyers were posted throughout the Department of Deaf Studies and Deaf Education building so that students were aware of the opportunity. Faculty also announced it in their classes and gave some students extra credit for participating. This resulted in a study sample comprised of 24 undergraduate ASL student participants. They represented Lamar's three Department of Deaf Studies and Deaf Education tracks. These tracks include ASL Teaching K-12, Educational Interpreting, and Advocacy.

Lamar ITP Students Using the Materials

To analyze our data, we organized our results around each of four research questions: 1) How do Lamar undergraduate students use the SBD, biology content summaries, and videos? 2) How effective are the SBD and content summaries in increasing Lamar undergraduate students' ASL biology vocabulary and biology content knowledge? 3) How effective are the SBD, content summaries, and videos in increasing Lamar undergraduate ASL students' capacity to interpret typical undergraduate biology lecture material accurately and fluently? 4) What additions and/or changes would make the materials more effective?

Key findings were as follows: Paired samples statistics and paired differences showed participants' knowledge of STEM vocabulary was significantly improved following use of the SBD (t (23)=8.14, p,.001; mean pretest=8.23 and mean posttest=36.56). Their ability to interpret typical biology lecture material was improved after learning the SBD vocabulary (t (23)=3.83, p,.001; mean pretest 2.5 and mean posttest=12.5). They also show that after watching the videos of the fingerspelling principles and working with the research team on applying those principles that fingerspelling scores significantly improved (t(23)=1.81, p=.04; mean pretest=9.8 and mean posttest=11.6). There was no significant improvement in participants' knowledge of biology content. (Questions 2 & 3)

Observations and post-use survey responses show that participants used the SBD, to look up terms and definitions in ASL and English; see words signed; view illustrations; learn new signs; and learn more about science. Most participants used the SBD to learn new signs and to learn the meaning of a term either because they did not know it or to help them review their knowledge of an aspect of biology content. They were generally satisfied with the information that was available for each term and with the accuracy of the signs but preferred a human signer to an avatar. All participants found that use of the dictionary made learning science terms and definitions easier. In general, they used the content summaries and found them interesting. (Question 1)

Based on participants' post-use survey responses, a revised version of the SBD that incorporates a human signer is needed. Additional and different materials and strategies are also needed to fully understand the meaning of STEM terms and to enable students to develop their understanding of fundamental STEM content incorporated into undergraduate lecture material. (Question 4)

WHERE ARE DOWNLOADS AVAILABLE?

For more information about our research and to access materials, visit our project website at https://signsci.terc.edu/

ACKNOWLEDGEMENTS

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AUTHORS

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RESOURCES

Signing Bioscience Dictionary

https://signsci.terc.edu/video/SBD/interpreters/

https://signsci.terc.edu/video/SBD.htm

Life Science Content Summaries

https://signsci.terc.edu/video/SBD/interpreters/

https://signsci.terc.edu/video/SBD/interpreters/content-summaries.html

Fingerspelling Videos

https://signsci.terc.edu/video/SBD/interpreters/index.html

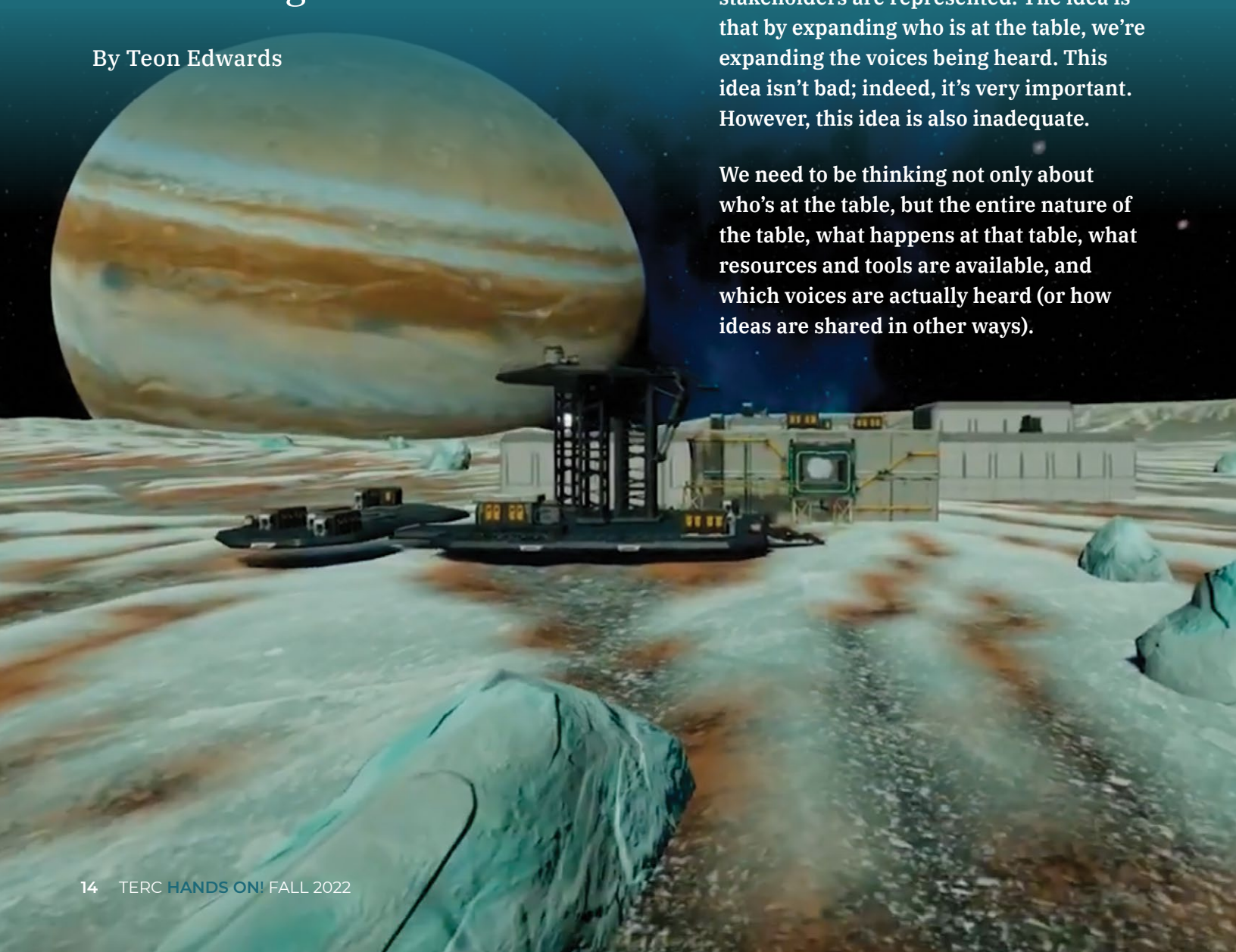
https://signsci.terc.edu/video/SBD/interpreters/fsprinciples-explained.html

https://signsci.terc.edu/video/SBD/interpreters/fsprinciples-review.html

More Than *Who's at the Table*

Co-Designing a STEM-Based Virtual Reality Game with Neurodivergent Learners

By Teon Edwards



When discussing diversity and inclusion, we often talk about changing who's at the table, about making sure women, people of color, and other often-overlooked stakeholders are represented. The idea is that by expanding who is at the table, we're expanding the voices being heard. This idea isn't bad; indeed, it's very important. However, this idea is also inadequate.

We need to be thinking not only about who's at the table, but the entire nature of the table, what happens at that table, what resources and tools are available, and which voices are actually heard (or how ideas are shared in other ways).

Co-Design

Just months into the COVID-19 lockdowns of 2020, the NSF AISL project *UniVRsal Access: Broadening Participation in Informal STEM Learning for Autistic Learners and Others through Virtual Reality* (DRL-2005447) was funded, with the goal of broadening participation in informal STEM learning by leveraging the unique affordances of VR for accessible and immersive science learning, designing for and with neurodivergent learners — learners with ADHD, autism, and other sensory, attention, and/or social differences. To achieve this, we embraced the neurodiversity movement's tenent "**nothing about us without us**" (Charlton, 1998), and co-design dominated the first two years of the project.

Co-design is the act of designing and creating ***with*** stakeholders to ensure the final products are usable by and address the goals and needs of the stakeholders. Ten members of our co-design team were undergraduate interns from Landmark College, a post-secondary institute specifically for students who learn differently. Some of these interns were involved for a semester, others a year, and one for two years. The other four co-design team members were education developers and researchers from the Educational Gaming Environments group (EdGE) at TERC. Together, we shaped the STEM-based VR game *Europa Prime* and related research.

Scaffolding

All the co-design team members had "a seat at the table," but this alone wasn't going to translate into everyone's ideas being "heard." While none of our neurodivergent co-design team members were non-verbal, there were definitely different levels of comfort, willingness, and ability with sharing ideas verbally. Thus, meetings had to be carefully crafted to meet the preferences and needs of the participants as a team and as individuals. For example:

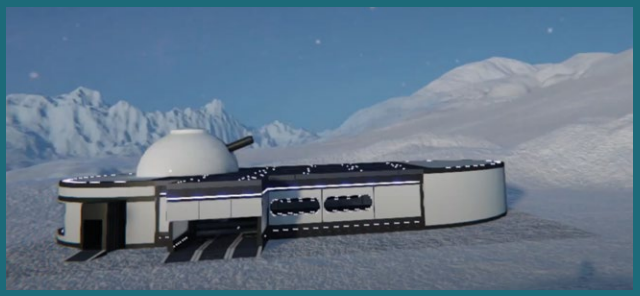
- Miro boards were used for brainstorming, feedback, and more. A specific question would be asked; everyone would generate ideas simultaneously, capturing them in just a few words; everyone would consider all the ideas without judgment, marking ones they liked, had questions about, or otherwise wanted to revisit; and only then would ideas be discussed.
- Each team member was regularly called upon by name, so everyone had opportunities to share. We put unique scaffolds in place to facilitate different individuals. Some members had a hard time talking when put on the spot, so back-channel communication via Chat was employed (e.g., "As soon as ___ is done, I'm going to call on you. Is that alright? Want to share about your ___ or ___ idea?")

Yes, being neurodivergent means you're not exactly the norm, per se, but being still treated just as a professional adult who just happens to have a few quirks or be a little bit distractible and get excited about ideas and will ramble on a tangent about it, and it's just rolled with, and it's often incorporated into the actual design... And having it be normalized, rather than being treated as other.

—KATHERINE HODER (LANDMARK INTERN)

Europa Prime

You awake in an unknown, futuristic-looking room. A small, friendly looking robot floats nearby. After poking around a bit, you manage to open some shutters. Out the windows spreads an icy surface with Jupiter hanging majestically in the sky. You're on a space station, apparently alone, and it's up to you to explore, discover, solve, and ultimately save the station ... and more. So begins the STEM-based virtual reality (VR) game *Europa Prime*.



Preliminary in-game scenes (MXTreality)

to give them time to gather their thoughts and not be taken by surprise. One member simply didn't want to talk some days, and that was accepted. Some members were perfectly comfortable talking, so their scaffolds related to distilling what they wanted to say as well as building awareness of when to give others a chance to speak.

- Specific options for in-meeting engagement were identified and implemented. For example, one team member explained they didn't feel a need to speak up if they agreed with what was being discussed. Since we didn't want to lose the vital information of agreement, the use of "agree" or a thumbs-up emoji in Chat was implemented and reinforced as a deliberate, predetermined means of sharing.
- Time and space were always given for being "off topic." One team member noted how important it was that the co-design process just "rolled with it" when they became distracted or rambled on a tangent. Such behavior had previously been treated as a problem or something to be curtailed; now it was being treated as an asset. It was important for team building, but also, interesting ideas often came up during these tangents or they were turned into opportunities to think about how the game could — and should — respond to players who were pursuing unintended directions.

Many other scaffolds were used during and between meetings. None of these scaffolds were, in and of itself, all that innovative—task templates can be useful, audio recordings are an alternative to writing, assignment descriptions can be highly specific or loose guidelines, drawings or online images can be used to capture ideas, and partners can assist each other. To facilitate co-design, the team put extra intentionality into finding and supporting different ways for each and every member to fully participate and help shape what was being developed. And more than any specific scaffold, co-design is about building relationships and trust.

The only time it is really treated as an other, is like a blessing, not a curse... It seems like you had this great gift of having a different perspective other people don't have by being neurodivergent. And so because of that we want to hear what you have... It's an other like a superhero, not an other like an outcast.

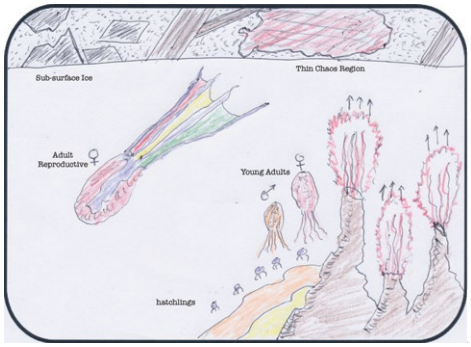
—STEPHEN SOLTERO (LANDMARK INTERN)

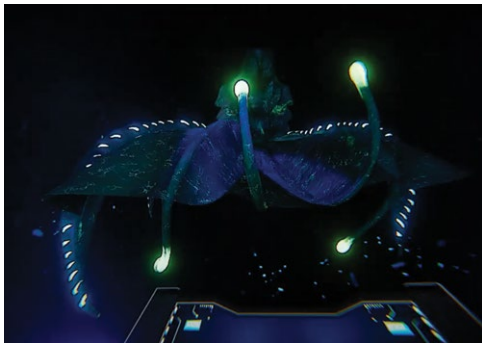
Reshaping

As part of a previous pilot project, some basic elements of *Europa Prime* had been developed and tested. Co-design team members largely embraced these pre-established elements; however, they also offered and pursued ideas for significant story alterations, backstory and character development, physical game controls, and more, reshaping the game in unexpected ways important to them. Sometimes these contributions were distinct from obvious neurodiversity considerations, such as with the design of the fictional Flame Jelly lifeforms introduced by a member interested in biology and animal behavior. Others struck to the heart of addressing the goals and needs of neurodivergent learners.

For example, several co-design team members proposed EM Spectrum puzzles as good STEM content with important sensory-input scaffolding connections. As the design process progressed, we saw that perceiving different wavelengths of EM radiation, including ones beyond the visible, could be analogous to challenges faced by some neurodivergent learners when sensory input is overwhelming, inaccessible, and/or incomprehensible. Also, as the team faced and addressed its own communication-related challenges, members used this experience to motivate the idea of integrating communication into the game. The need to figure out how to communicate across various divides became an in-game means of addressing social differences.

Bringing together these and other design ideas, the team devised and crafted the Minos, fictional cephalopod-like aliens who communicate using the EM spectrum, but only at very low brightness levels (as bright lights can overwhelm) and only partially in the (so-called) visible (as perceptions can differ). The Minos communicate by flashing sequences of different colors, including in ultraviolet wavelengths. Just as learners with autism may experience sensory integration differently than (so-called) neurotypical learners, the player and the fictional Minos are receptive to different sensory input and must find common understandings and establish basic levels of communication. And this is just one example of how the co-design team has addressed fundamental aspects of the proposed project—STEM learning, sensory differences, and social scaffolding—in ways that wouldn't have come about without the central involvement of neurodivergent members of the team.





Ecosystem and Minos sketches and preliminary artwork (Jamie L, Daniel L, and MXTreality)

Conclusion

Engaging in authentic co-design requires:

- Listening with empathy
- Treating team members as whole people, not just whatever "got them" their seat at the table
- Learning what each individual needs/wants to comfortably share ideas... and then implementing
- Providing EVERYONE with multiple ways of capturing ideas
- Allowing for naturally generated team building
- Using names — calling on people and crediting people
- Planning and scaffolding all meetings and tasks carefully
- Building in time for distraction and tangents; this isn't wasted time
- Practicing patience and open-mindedness as plans take detours and change course
- Building relationships and trust
- Taking risks and (for leaders) giving up (full) control

Doing this can be challenging and time consuming, but it's worth it, as co-design has the potential to be transformative. What's happening at your table?

Check out more about co-design, the project, and the transition from design to development at edge.terc.edu and https://www.terc.edu/projects/univrsal-access/

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UniVRsal Access co-design team: Zachary Alstad (EdGE), Gerald Belton (Landmark), Ibrahim Dahlstrom-Hakki (EdGE), Teon Edwards (EdGE), Ian Hagberg (Landmark), Katherine Hoder (Landmark), Jamie Larsen (EdGE), Daniel Lougen (Landmark), Nicholas Payne (Landmark), Daniel Santana (Landmark), Becky Scheff (Landmark), Stephen Soltero (Landmark), Ben Stafeil (Landmark), and Zack Steinbaum (Landmark), as well as Bennett Attaway (observer from Knology, the project's external evaluators)

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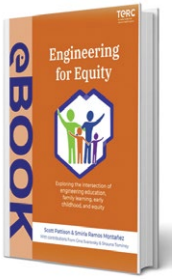

TERC researchers Scott Pattison and Smirla Ramos Montañez reflect on assumptions, learn from others, and explore new ways that their research could both uncover and help dismantle inequities and racism in the STEM education system.

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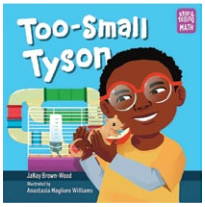

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