Including Individuals with Disabilities in STEM Courses, Research, and Careers
Multiplex Theme of the Month Synthesis
March 2021

Introduction
In this month's theme, our facilitator and expert panelists have helped us explore projects that are attempting to break down attitudinal, physical, and technological barriers so as to make STEM fields more welcoming and accessible to students with disabilities and all students.

The panel. The facilitator for this month's Theme was Richard Ladner, Professor Emeritus of Computer Science and Engineering at the University of Washington. Sheryl Burgstahler is the Director of Accessible Technology Services and the DO-IT center which stands for Disability Opportunities Internetworking and Technology at the University of Washington. Jeanne Reis is the Co-Director of the ASL Ed Center in Boston. Emily Moore is the director of research and accessibility for PhET interactive simulations in the department of physics at the University of Colorado Boulder. (For more background, see this Theme's overview page.)

The expert panel highlighted three major themes exemplified in their own work and reflected as well in more than 50 videos on the Multiplex, from which the Theme's playlist of ten videos was selected.

1. Translating modalities.

> *Developing inclusive learning tools means creating learning tools that have a design and architecture that supports multimodality and flexibility. So not just designing and building visual displays, but also auditory and haptic and tactile displays. And not just supporting mouse and touch input, but also alternative inputs, gesture tracking and object tracking. And doing so in a way that enables teachers and learners flexible use, accessing different features in different combinations for individuals in collaborative groups, in-person and remotely. -- Emily Moore*

The PhET project at the University of Colorado has developed hundreds of physics simulations designed to support hands-on physics learning; these simulations are very widely used in secondary and post-secondary STEM education. All digital simulations represent a simplification of the situation being simulated, since they are not able to recreate all the sensory and contextual elements that are part of an "in person" experience. The intensely visual character of these simulations, however, represents significant barriers to visually impaired users, and other aspects of the interface present difficulties to, for example, students with limited motion. A significant dimension of this situation is that "the vast majority of students with disabilities are taught physics in general education classrooms." (Perkins and Moore 2017) This naturally represents a real burden to teachers, who as a consequence must find ways to teach students with a wider range of capacities. PhET developers sought to design simulations with such classrooms and teachers in mind.

In several years' research and development, Emily Moore and her colleagues explored the nature of these barriers, and possible ways to surmount them. An early adaptation, text that can be read by a screen reader, was helpful, and was followed by narrative embedded in the simulation itself, so that an independent software tool was not needed. Text and narrative, however, were not adequate as a way to convey processes changing over time, which might be represented visually by color changes, rising indicators, and the like. This led to innovations in the use of sound as a way to represent such changes. These and other innovations are inclusive in more than one way, since in addition to helping the visually impaired students, they also provide additional support to normally sighted students.

All these innovations are rooted in extensive, continuing research in collaboration with persons (especially students) with disabilities, and with teachers. Technical innovations, including developments in modifications to HTML5 capabilities, as well as simulation design, are developed in tandem with user input, as well as the constraints imposed by the science being simulated.

2. American Sign Language enriched for STEM.

As Richard Ladner pointed out, American Sign Language (ASL) is now the third most popular language taught in college. This visual language has unique linguistic features — syntax, semantics, and stylistics — not present in English. As Jeanne Reis said "English happens to be, for example, a noun-loving language, we like to make nouns out of verbs.... ASL is a verb-loving language. So instead of signing 'photosynthesis,' you might be signing 'photosynthesize.' The process itself is the sign that emerges as the accepted sign. And one that's more functional in use."

The process of creating new STEM 'vocabulary' for ASL drives other development in materials, including reference materials for ASL speakers. Reis pointed out that "Signs are signs, but they are only used in context. So you really have to see them used in context." For this reason, video is an important component of websites and other materials supporting ASL use in STEM courses and informal settings. This requires adaptations not only by developers, but also by educators who are not used to teaching with such multimodal materials.

Moreover, ASL has dialectal variations like any other language. It does not, however, have a standardizing institution that regulates the introduction of new terms to the language such as exist for some languages. So new 'vocabulary,' i.e., new signs, originate in many places in the signing community, and are spread within the ASL community by various informal means. In response to this, Reis and others take advantage of the Web to create a national database, where "candidate" signs can be disseminated, evaluated, and debated to facilitate the identification and use of effective additions to the ASL lexicon.

I don't think of my work as serving the needs of a disability as much as I see it as serving the needs of a language minority population. And in serving the needs of many who don't know that they will eventually become hard of hearing or become deaf across the lifespan. So many of us are currently having access to a range of sensory information and that changes across a lifespan. So I think of all of us as somewhat temporarily abled or disabled in various categories in our lives. So the work that I do is to bring some additional resources to the STEM fields -- Jeanne Reis.

3. Opportunity networks.

In addition to specific practical challenges that exclude people with impaired abilities — and this they have in common with other underserved populations — is lack of access to the networks and information about STEM education and careers that are designed and taken for granted by majority students. Sheryl Burgstahler told us DO-IT (Disabilities, Opportunities, Internetworking, and Technology) serves to increase the successful participation of individuals with disabilities in challenging academic programs and careers. As with the other approaches mentioned above, this is deeply contextual work — addressing specific technical supports, but also connecting students to mentors, to peers with shared interests and ambitions, to educational opportunities, and to placements in internships in the private sector. This in turn means working with the schools or companies to facilitate their inclusion of people with disabilities in ways that make success more likely for all concerned.

We work with individual students with disabilities, all types of disabilities. We're concerned with transition. So we're talking about transition to a post-secondary school, maybe to graduate school, maybe to a career... We also work with faculty and staff and institutions and companies, where proactively we help them make whatever they're developing... This is underpinned by the social justice model of disability. And also, an ability focused model. So universal design is used as an approach to solve these accessibility problems. -- Sheryl Burgstahler.

4. Diversity as a strategy for better design.

What strategies have been developed to include and empower more individuals with disabilities in STEM fields? The panelists mentioned several:

Innovation happens at the margins. In other words, if inclusion is your aim, a good strategy is to design for those most marginalized, or whose challenges seem hardest to address. In Emily Moore's account, this challenge started with the visually impaired.

Once progress started there, she said:

We started a virtuous cycle of innovation and inclusion, noticing how one new design feature positively impacts other learner communities. Anyway, as we expand our work to include other learner communities, we identify opportunities for new features and so on and around and around it goes.

Jeanne Reis, in response to this question said:

I think that the very first thing I continually learn is how much I don't know, and how much fun that is actually to be in that space of learning all the time. And how much we all don't know. How much technology doesn't know. How much our systems don't know about how to operate really for the benefit of all. And so I think that learning is always a really important element of being inclusive in general. So in the community that I work with, my collaborators, my deaf colleagues, we are often struck by the mutual benefit of this co-design process...So, being willing to learn, being willing to use other senses to engage with new communities.

Sheryl Burgstahler added:

When we talk about universal design of something it will be something that is accessible and usable, but also inclusive. People with disabilities can participate side by side with other students, whether it's online or onsite. And then empowerment goes hand in hand with self-determination so that students can develop skills and knowledge so that they can maneuver in this world that's really not very accessible to them.

Finally, design and research need to be inclusive from the beginning: if you're exploring working with a new community or a new group of individuals, students, or colleagues it may be to really be led by that community. This methodological principle (see Ladner et al. 2020, Stefik et al. 2019, Perkins and Moore 2017) is a hallmark of groundbreaking work in this field.

Recommendations for researchers

Much work needs to be done to understand the implementation and effectiveness of different differentiation practices: What works? What doesn't? Under what conditions? What resources can make a difference? How available are such resources?

What kinds of redesign or accommodation can make physical lab activities more accessible to students with various limitations? (See Perkins and Moore 2017)

What methodologies need to be developed or adapted to study the value of various kinds of accommodation and the contextual dynamics that support or inhibit effective implementation?

Recommendations for teacher-leaders and administrators

Teacher leadership is exercised as instructional innovators, as professional developers, as coaches for their colleagues, or as advocates for educational change and teacher support. In each of these roles they can help by encouraging learning community work around inclusion in STEM.

An important area of interest is creating collaborations between STEM teachers and special needs teachers. The former may not have much experience with inclusive practices, while the latter may have little understanding of the particular nature of STEM learning and pedagogy. How can this divide and difference in areas of expertise be bridged? An early study (Mutch-Jones et al. 2012) explored the possibilities of Lesson Study as a method for collaborative learning. A key finding from this study is that the process is not a swift one — like any pedagogical change, the teacher's changing repertoire has to be integrated with the constraints of their subject matter, and the integration and evaluation of new pedagogy is in practice, and in reflection on practice. This means time and space in teachers' schedules for the design and evaluation of experiments in teaching, and for special needs teachers to understand how their particular insights can be integrated with STEM process.

References

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