Science Education at the Crossroads

Montgomery, Alabama

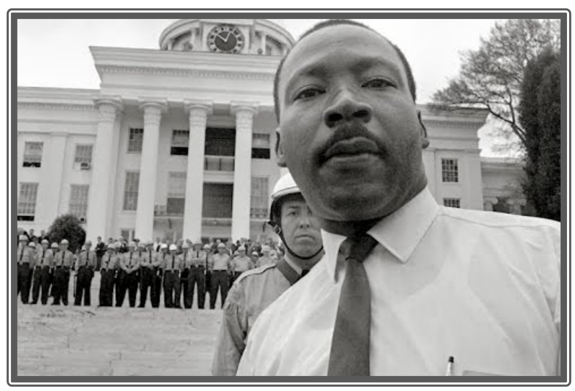
November 6-9, 2019

Dear Crossroads Attendee,

Welcome to Montgomery and the Science Education at the Crossroads conference. The first Crossroads in 2005 was a revolutionary act against the oppressive dullness of research conventions that shall not be named. Although our conference has matured in many ways, it still maintains the touches that make it distinctive and generative. Everybody who attends must be a presenter. A premium placed on question-posing and joint problem solving. The sessions are deliberately low-tech because we feel it's important to focus on the people seated around the table. Even though we could figure out an electronic version of the Proceedings, we know that digital devices tempt distraction ("click me, like me, follow me"). Crossroads is about listening and offering helpful perspectives.

We chose the theme of ***Equity in STEM Education Leadership*** to recruit professionals with similar commitments in usefully different contexts. The theme also resonates with the conference location -- for which we are eternally grateful to André Green who recommended this site to us. As is often the case, we failed to fully realize the importance of our choices until we were well on our way. During our June site visit, we discovered much more than we had anticipated. Not only did we develop an appreciation for Montgomery, we stumbled upon history and geography that astonished and changed us. We discovered many realities from the past that persist into today.

In March 1965, marchers took five days to make their way to Montgomery from Selma. State troopers on the Capitol's steps blocked Dr. King from meeting with Governor George Wallace. That moment is captured here as if the civil rights leader took a selfie. Glancing to his left, Dr. King would see the church where he first served as minister. Past the photographer, he could look down Dexter Avenue toward the fountain that graces the Proceeding's cover.



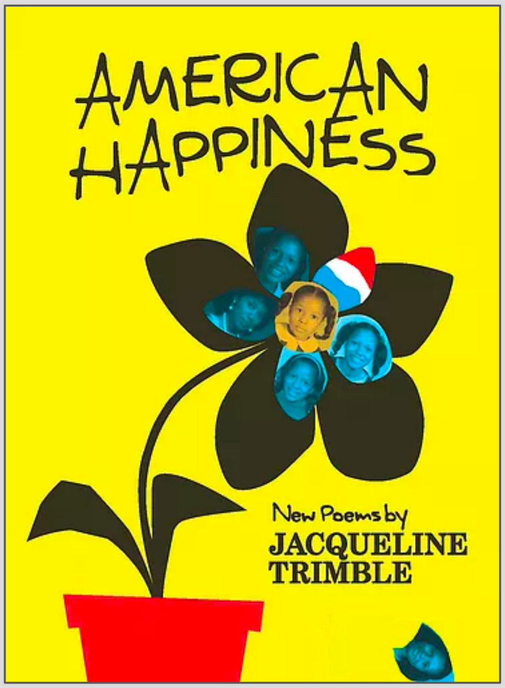
Almost 55 years later, so much has changed and yet so little. More work still needs to be done. This includes becoming more conscious of Montgomery's long, tragic histories prior to the event captured in this snapshot. That's what we discovered when we first came to Montgomery. Now on our second trip, we've made arrangements for you to also visit these key sites. We're honored you made time in your busy lives to spend a few days with us. We greatly appreciate the participation at Crossroads by every one of you.

Thanks for being present and willing to share yourself with us!

John and Adam

FEATURED POET

JACQUELINE ALLEN TRIMBLE lives and writes in Montgomery, Alabama, where she is a professor of English and chairs the Department of Languages and Literatures at Alabama State University. Her work has appeared in various publications including *The Griot, The Offing, The Louisville Review*, and *Blue Lake Review*. *American Happiness (2016)*, her first collection, published by NewSouth Books, won the Balcones Poetry Prize



"I became the only black child in Davis Elementary that year. I joined the Brownies, and my mother joined the PTA. Whatever minor skirmishes or major wars ensued behind my being at the school, I never heard of them. In those days, children minded children's business and adults minded their own. Neither inquired about the doings of the other. What I do know is that fall my mother volunteered to read palms at the fall festival. Dressed in a long flowing skirt and a peasant blouse, she played the part of fortune teller. Children and adults alike entered her small booth to have Mama gaze into her magic eight ball and tell their fortune. I went dressed as a ghost. The only little black child in the whole school wandering the halls of the festival in a sheet with a pointed pillow hat in which my mother had cut two little eyeholes. It was years before I understood why my mother laughed and laughed and took so many pictures of me in my white sheet that night. Even then she was teaching me the power and pleasure of ironic juxtaposition—a lesson that continues to inform my sense of humor as well as my poetry."

INCUBATOR SESSIONS

With the goal of nurturing and hatching projects, sessions are called Incubators. Each Incubator includes two presenters and an audience of self-selected participants gathered around a conference table. Incubator sessions are 75 minutes long. Each presenter is allocated 35 minutes. A Facilitator is present to keep track of time and ensure the session follows this very precise schedule:

- **10 minutes for the presenter to describe their Vexation and Venture,**
- **5 minutes for the participants to ask clarifying questions of the presenter,**
- **15 minutes for the participants to discuss the presenter's Vexation and Venture — without any input from the presenter, and finally**
- **5 minutes for the presenter to speak whatever is on their mind.**

In the schedule, the two Presenters are listed for each Incubator along with the designated Facilitator. The Facilitator runs the session and controls turn-taking. No appeals, no negotiation.

THE FACILITATORS

Crossroads is highly dependent on its unique structures and traditions. Reinforcing these norms possible via the actions of our Facilitators. Their purpose is to create the proper environment so everyone benefits from the Incubator sessions. They are best characterized as endearing taskmasters. We believe that these structures offer considerable freedom.

Our four Facilitators are volunteering their time. Their efforts make all the difference and allow the organizers to participate in their own conference. Don't fear the Facilitators. But do respect them for what they do and make possible for the rest of us.

Becky Pengelly	**Dionne Wilson**	**Clausell Mathis**	**Beth Raynor**
Florida State	*Florida State*	*Florida State*	*Manchester High*

INCUBATOR ETIQUETTE

Crossroads has a distinctive culture that relies on these norms:

1. We discourage moving between rooms during the Incubators. While such practices are common at other conferences, it runs counter to the climate we foster at Crossroads.
2. We encourage uniform distribution of attendees across sessions. If you notice a crowded or sparsely populated room, consider doing your part to balance the numbers by being generous with your presence.
3. Similarly, we encourage equitable opportunities for people to contribute to the discussions. If you've not spoken, pipe up if it's quiet. When you have shared thoughts, allow the discussion to flow around you. Most discussions flow naturally in generative ways, and we attribute this to openings for talk and being comfortable listening.

CITING YOUR CONTRIBUTION

We recommend incorporating your Crossroads participation into your c.v. or resume. There are two options you might use, the first as a paper presentation:

Your name. (2019). *Title of your talk*. Paper presented at the national meeting of ***Science Education at the Crossroads***, Montgomery, AL, November 6–9 [Available online at sciedxroads.org/confer/proceedings/].

You could also cite your work as a refereed paper in a publication:

Your name. (2019). Title of your talk. In J. Settlage & A. Johnston (Eds.), ***Proceedings of the Science Education at the Crossroads Conference*** (pp. xx-xy). Montgomery, AL. [Available online at sciedxroads.org/confer/proceedings/].

CONFERENCE SCHEDULE

Wednesday, 6 November 2019

2:00 – 7:00 pm	Arrival	**RENAISSANCE MONTGOMERY**	201 Tallapoosa St.
7:00 – 8:00 pm	We Begin	**Reception and Welcome**	*Star Light Foyer*
8:00 – 9:00 pm	Orientation	Incubator Rehearsal	
after hours	Networking		

Thursday, 7 November 2019

8:30 – 9:00 am	Welcome	**Re-Welcome & Fresh Introductions**	***MONTGOMERY 3***
9:00 – 10:00 am	**Keynote Addresses**	*Brian Williams, Adam Johnston & John Settlage*	***MONTGOMERY 1***
10:00 – 10:30 am	Break		***Foyer MGM 1***
10:30 – 11:45 am	**Incubator A**	1. Heidi Carlone & Stephany Santos [Clausell]	***Riverview 1***
		2. Noemi Waight & Mark Enfield [Becky]	***Riverview 3***
		3. Andy Gilbert & Michelle Brown (CZS) [Dionne]	***Riverview 5***
12:00 – 1:00 pm	Lunch		***Foyer MGM 1***
1:15 – 2:30 pm	**Incubator B**	1. Sherry Southerland & Leah Champ [Dionne]	***Riverview 1***
		2. JD McCausland & Sumi Hagiwara [Clausell]	***Riverview 3***
		3. Rachael Gabriel & Teresa Shume [Becky]	***Riverview 5***
2:30 – 3:00 pm	Break		***Foyer MGM 1***
3:00 – 5:00 pm	**WALKING TOUR**	**Expedition to Rosa Parks Bus Stop** **Court Square Fountain**, and **Dexter Avenue King Memorial Baptist Church**	
5:00 – 6:55 pm	Free Choice	Dine and Unwind	
7:00 – 7:30 pm	**Dessert**	Pre-poetry reception	***Riverview 4***
7:30 – 8:30 pm	**KEYNOTE**	**Dr. Jacqueline Trimble**, *Poet and Professor* author of ***American Happiness***	

Friday, 8 November 2019

9:00 – 10:15 am	**Incubator C**	1. Stefanie Marshall & Patrick Enderle [Beth]	***Riverview 1***
		2. Asli Sezen-Barrie & Stacy Olitsky [Dionne]	***Riverview 2***
		3. Kathryn Ribay & Christa Haverly [Becky]	***Riverview 3***
10:15 – 10:45 am	Break		***Foyer MGM 1***
10:45 – noon	**Incubator D**	1. Scott McDonald & Alanna Cooney [Clausell]	***Riverview 1***
		2. April Luehman & Maria Gonzalez-Howard [Becky]	***Riverview 2***
		3. Jessica Thompson & Greses Pérez-Jöhnk [Beth]	***Riverview 3***
noon – 1:00	LUNCH		
1:00 – 1:30 pm	**EJI Preview**		***Montgomery 1***
2:00 – 3:30 pm	**Memorial**	**National Memorial for Peace and Justice**	417 Caroline St
4:00 – 5:30 pm	**Museum**	**From Enslavement to Mass Incarceration**	115 Coosa St
6:30	Group Dinner		

Saturday, 9 November 2019

9:00 – 10:15 am	**Incubator E**	1. Manali Sheth & Doug Larkin [Dionne]	***Riverview 1***
		2. Bhaskar Upadhyay & Hanna Sevian [Beth]	***Riverview 2***
		3. Brian Williams & Katherine Hayes [Clausell]	***Riverview 3***
10:15 – 10:45 am	Break		
10:45 – noon	**Incubator F**	1. Terrell Morton & Adam Johnston [Becky]	***Riverview 1***
		2. Alexis Patterson & John Settlage [Dionne]	***Riverview 2***
noon – 1:00	LUNCH		
1:00 – 4:30 pm	**Tourism**	*Visits to Montgomery Sites* **Rosa Parks Museum, Freedom Rides Museum, & NewSouth Bookstore**	***Montgomery 1***
5:00 – 11:55 pm	FREE TIME	Enjoy Montgomery!	

Vexations

My goals were initially modest; work with a small team of teacher educators and elementary teachers to regularly integrate reform-inspired science and engineering into the curriculum at schools that served high populations of minoritized youth and were labeled "underperforming" by the state. In 2013, we partnered with 6 teachers. This seedling blossomed into the STEM Teacher Leader Collaborative (TLC) (www.uncgtlc.org), a network that includes approximately 230 elementary teachers, most of whom teach in schools impacted by the education debt—a combination of historical, economic, and political realities that perpetuate unjust education conditions, such as segregation and inequitable funding (Ladson-Billings, 2006). Our goals are: (1) nurturing STEM equity among students; (2). Empowering and retaining teacher leaders; (3) Creating a "we" culture among teachers (Carlone & Smithenry, 2014). The work has evolved, and I now have a more ambitious aspiration: ***Could equitable science and engineering instruction be a regular feature in all high-needs elementary schools in the North Carolina Piedmont?***

This work has persistent vexations related to strategic growth, sustainability, and funding that we have explored in large charrette-style meetings with stakeholders, multi-day workshops, incubator-inspired sessions with UNCG faculty, and brainstorming meetings with a local foundation Director. The infrastructure is stronger. Now, however, I need help to dig into the substance and tensions inherent in doing this work.

Encouraging the disruption of raced and gendered constructions of "elementary teacher" from positions of privilege. The culture of surveillance and standardization in high-needs elementary schools shapes teachers' practices and agency (Giroux, 2005). When designing professional learning in *science*, we must consider that elementary school contexts often diminish or ignore teachers' efforts to include science in the curriculum. This becomes more complicated when considering historical, gendered, heteronormative, and raced constructions of "good elementary teachers" (e.g., as nurturing, humble, compliant pleasers) (Zembal-Saul, Carlone, & Brown, in preparation). Ladson-Billings (2009), for instance, provides a compelling case for how and why Black women teachers are rarely held up as exemplary teachers. In high-surveillance cultures, gender and teaching performances that fall outside normative subject positions are admonished and even punished. High-stakes testing also reproduces neoliberal, masculine competitive practices, whereby good teaching is a zero-sum game aimed at improving test scores, thwarting efforts of professional collaboration and collective agency (Zembal-Saul, et al., in preparation).

The STEM TLC must begin to address these tensions. My positionality as a cisgender, White woman with a university position is privileged and partial. The two STEM TLC coaches are White, cisgender women doctoral students who taught in local, high-needs elementary schools. We represent privileged positions in the matrix of oppression (Collins, 2000). Approximately 25% of teachers in STEM TLC are women teachers of color; many of these women are more comfortable taking on the "tempered radical" identities we promote (Carlone, Haun-Frank, & Kimmel, 2010), though that agency ebbs and flows throughout the year (Mercier, Carlone, & Blankmann, 2019). We regularly recruit teachers of color to serve as teacher leaders and to co-present at regional conferences. Next steps would include combining efforts to support equitable STEM pedagogies and identity work entangled in enacting those pedagogies.

Recruitment and representation. We made a concerted effort to recruit teachers directly, rather than going to principals or district leaders first, which is a shift in how our district operates. This was part of our commitment to treat teachers as professionals who could make their own decisions about their professional learning. We found that teachers most motivated to integrate science and engineering into their curriculum were most likely to act as leaders for their grade-level teams. Our network has grown primarily through teachers who work with/tell other teachers about what they learn in our programs. Though we have a diverse teacher leader team, we need to do a better job recruiting a leadership team of *predominantly* teachers of color for our summer institutes because they are often well positioned to model successful ways to navigate oppressive systems, fight for justice-centered pedagogy, and provide expansive, inclusive models of "good teachers". However, many find it difficult to take time away from families during precious summer months. Further, many cannot pursue doctoral work full-time because of financial responsibilities, nor do we yet have funding to create STEM teacher leader positions that provide livable wages.

Job-embedded professional learning: More "effective" but difficult to sustain. Initially, our professional development included a Summer Institute and one or two follow-ups during the school year. We knew this was not enough. Regardless, teachers loved this PD. Our evaluations were consistently excellent, and our Collaborative became better known in the district among teachers. Further, we saw changes in science instruction at schools where more teachers and resources were invested in STEM. We also successfully recruited a cohort into our new MED elementary science education program. With more funding, we added an annual STEM TLC Advanced Institute and invited STEM Teacher Leaders to co-facilitate the Introductory Institute. Last year, we piloted "Communities of Inquiry" (COI)—semester-long PD for small groups of teachers, adapted from Thompson, Hagenah, McDonald, & Barchenger's (2019) model of PD (i.e., studio days and co-planning/reflecting in schools). The COI groups demanded more time and commitment. Those who regularly attended were unanimously positive about their experiences, claiming increased science test scores, collective agency, confidence, and readiness to continue COI this year. Other groups floundered, with attendance spotty, people dropping out, and one group dissolving altogether.

Top-down buy-in. Leadership in schools and at the district level are largely ignoring our efforts. District leaders have attended workshops with us, participated in two charrette-style meetings, attended Summer Institutes as guests, and celebrated our efforts with retweets. The superintendent has visited and lauded STEM TLC classrooms publicly. However, when it comes to offering and co-designing district-level PD or leveraging the growing wisdom of the STEM TLC teacher leaders, the district and school leaders overlook our network as a resource.

Venture

Treating teachers as professionals means taking seriously the contexts in which they work. Greensboro, NC's history is rife with racial tensions that persist today with the city divided between the mostly minoritized east side and the mostly White west side. The STEM TLC's partner schools are mostly on the east side. The city was also catalyst in the civil rights movement when in 1960 four young African American men staged their historic sit-in protest at a segregated Woolworth's lunch counter. The city's immigrant and refugee populations are growing. Given this context, growing a network of teachers committed to and supporting one another in justice-centered pedagogy is critical and possible. STEM TLC teachers rely on one another for advice, professional camaraderie, and collaboration. The culture of our group is becoming more established, as the advanced institutes and teacher leader workshops have a reunion-like feel. This work is both more rewarding and challenging than I thought it would be.

a. What can we do to enable the district leaders to position the teachers in the STEM TLC as resources for the district? At least 25 or more of our teachers are poised to take on substantive STEM leadership roles in the district, with more in the pipeline.
b. What have others done to sustain commitment to longer-term PD over time? Are there ways to leverage teacher-leadership to maximize teacher retention?
c. We need to organize professional learning that supports equitable, disciplinary pedagogies and identity work implicit in enacting those pedagogies. We are, after all, asking them to take on identity work that may be uncomfortable, not rewarded, positions them as outsiders, and/or punished. I worry about suggesting subject positions that may be risky for teachers yet easy for us to suggest: How do others navigate these moral and ethical tensions?

Struggling to Lead for Science in an Urban Environment

Leah Champ Burdick, *New London (CT) Public Schools*

Vexation

The issue that I am struggling to overcome in STEM education leadership as it concerns to equity is why so many inner-city schools completely cutting out science — specifically the one I work in. New London Public Schools is becoming the first all-magnet public school district in Connecticut. That means there are 3 themes for the elementary schools: STEM, Arts, and Internal Baccalaureate/Dual language. Currently, New London educates slightly over 3,000 students with 81% of the school population classified as ethnic "minorities." 70% of the students qualify for free/reduced lunch and 22% of students struggle with chronic absenteeism.

When I began working in the district I was the STEM Coach at a K-5 STEM magnet school. My job included attending extensive training, alongside classroom teachers and administrators on Inquiry-based learning, NGSS other science related initiative. And the school had a positive reputation with a waiting list of families who wanted to enroll their children. Because this school had a large amount of supplemental funding because as part of the state's desegregation orders we were able to provide teachers with this amount of training year after year. Consequently, teachers became comfortable in their science teaching abilities and there was very little teacher turnover. I now work in the same district but in a school with a Dual language and International Baccalaureate (IB) theme. Last year I was one of two assistant principals but when the principal left during the summer, the other assistant became the building principal and I absorbed the responsibilities once distributed between two administrators. As a leader of an elementary school, I aim to coach teachers to deepen their practice. I am responsible to provide them with the knowledge and materials that may be lacking in order to meet the expectations for teaching at a particular grade level. In addition to that I am responsible for the day to day routines, behavior management and to sit in special education meetings. At this school little to no science is being taught, aside from the test prep which occurs over a few days prior to the state mandated fifth grade science test. The schools' reputation has a less desirable magnet appeal. We do not have the students from out of town asking to come in and therefore the funding that would come from each out of district student is not flowing in to this building like it did with the STEM-themed school. My current school continuously underperforms on the state tests and teachers are ultra-focused on these state tests (which only assess math and reading, with the exception of 5th grade with an added science test). Not only is school funding inequitable but my students receive fewer resources and access to science curriculum. I witness students in the same district receiving completely different levels of science opportunities.

One might reasonable expect that because a STEM school would offer enriched amounts of science as opposed to the Dual Language school or the Arts schools because of the different thematic focus. But I am speaking about the <u>basic</u> elementary science curriculum all students should have access to. As a side note, math is also a focus for a STEM school but no one would propose that an IB or Art elementary school would not need to teach math. Numerous children will go through elementary grades in my district but with nowhere close to having equivalent options to engage in science. That is highly concerning. One reason is that we are taking the inquiry out of learning. Science is full of wonder as children are asking why. By not teaching science we are doing a disservice to our students.

I went through 3 summers of training for 'Inquiry-based learning' at Mandell Academy, as well as I was part of the NGSS Training group at the Connecticut Science Center. In addition to science training an educational leader is trained on curriculum development, teacher effectiveness and a host of other areas that are addressed within the walls of the school. With all of that training, I had imagined that I would lead a school superior in science academics. I felt confident that I could facilitate data teams and professional development that excited teachers, giving them the knowledge, curriculum and materials needed and in turn excited students in the area of science and/or science integration.

Venture

My position as an Assistant Principal allowed me to open doors for more science education. Last school year I was able addressed the issue by writing a large grant for low-performing schools that included funding for science materials. I created a "Collaboratory" space within our building with tables set ups for small groups, screens to present research projects, and an entire science curriculum that included lab materials and consumable books for the students. My hope was that by giving the teachers everything needed, including a dedicated and designated room, that they would feel receptive to teaching science. The first issue that I had with obtaining the grant was that the state said too many of the science materials were consumable products and grant money couldn't be used in that way. Instead, the grant funds could only be used for materials including technology pieces such as a touch screen, small computers grouped together so to provide group work stations, round tables and chairs. The additional materials I had incorporated to make this room a science "Collaboratory" was science curriculum. This curriculum came with teachers' edition books, student books and all materials needed to set up the experiments included in the curriculum. Teachers often complain they spend so much of their own money on the students and the classroom and that they do not want to add one more thing by having to buy the materials (consumable as they may be) for the curriculum. So the grant provided everything except the science materials.

The next issue that I ran into with grant was that no one at the district level was in charge of science. This translated into the project, its money, and the science materials dropped through the cracks. Even though a comprehensive list with every detail was present, chairs weren't ordered for the tables, the equipment was ordered but without a plan for installation — and the list goes on. The current state of the room is that we've had a few desks brought in along with a few chairs. Meanwhile, the screens remain in their packing boxes. The final issue is that teachers want to be given the curriculum and all materials that go along with it. They feel overworked and don't have any extra time to go out and find materials and activities to match the ever confusing NGSS. When you teach math, you are given a curriculum, a teacher manual and all of the materials needed —workbooks and assessments and manipulatives. My teachers have the same expectations about science. Therefor the "Collaboratory" represents a wasted space that is not even halfway finished. We still have none of the consumable science materials and very little science being taught in the building overall.

My questions for consideration are:

1. How might I convince the district to invest in science above and beyond the funneling of science money along the STEM pathway?
2. What can I do to get science materials into the hands of teachers in my building in the least?
3. How can I begin to get the community to come together to advocate for science in every classroom?

Equity in STEM Education: Fostering a Collaborative Culture among Science and ESL Teachers to Support Long-Term English Learners within a Middle School Setting

Alanna Cooney, *Rogers Park Middle School – Danbury, CT*

Vexation

Rogers Park Middle School is an urban middle school with a student body of 1,026. As of the 2019-2020 school year Rogers Park became a Title I school. Our student demographics are 63% Hispanic/Latino, 23% White and 6% Black. Of this student body, 29% are labeled as an English Language Learner. We have had 150 (and counting) new students enroll at Rogers Park since the end of the 2018-2019 school year: 55% have been labeled as an English Language Learner.

English Language Learners (ELLs) are identified by their Language proficiency test scores (LAS Links score). LAS Links scores are based on a student proficiency in listening, speaking, reading and writing in English. The scoring is based on a 1-5 scale, 1 being Beginning and 5 being Above Proficient. To exit out of the English as a Second Language (ESL) program a student must score a minimum of 4 on reading and writing, as well as an overall score of 4 for all categories. These scores are used by teachers to determine the types of modifications and support each student needs to succeed in the classroom.

The LAS Links scores are then combined with the student's entry date into the district. Students who are new to the district and/ or country are enrolled in the New Arrivals program until they are able to be tested and placed in mainstream classes or upon completing the program. This program is intended to teach students English that is necessary to be successful in a school setting. Students who have been enrolled in a U.S. school for over 6 years, but have not tested out of the ESL program, are considered a Long-term English Learner (LTEL). These students show limited or stagnated growth in English proficiency, usually in reading and writing. Once labeled an LTEL, it is extremely unlikely the student will ever exit the ESL program before graduating high school.

During the 2018-2019 school year, ELL students were placed in classes with students who had similar LAS Links scores. These classes would be co-taught by a content teacher and an ESL teacher. Students exiting the New Arrivals program or have a LAS Links score of 1 or a low 2 were placed in classes together, while students with a score of a high 2, 3, or 4 were placed together in another. In my science classroom, I had students with scores of 2, 3, and 4s. My co-teacher and I worked together daily to modify lessons so my students could interact with science content and achieve the same standards as their peers. My students showed a passion for scientific inquiry, and this inspired me to work harder to provide more opportunities to explore on their own. The connections they made with the content continued outside of the classroom and into their everyday lives. They loved sharing stories of how they showed their family the polymers inside of diapers or how their breakfast was now in their small intestine and giving them nutrients for the day.

While there was success with the co-teaching approach, there was concern that ELL students were not being exposed to the English language the way other students were. My worry was that this would contribute to, or even increase, the language gap and make it more difficult to meet grade level standards long-term. ELL students would also be isolated from their peers and not form connections with them. This would lead to them being referred to as 'those other students' or 'the spanish kids.' This began to hinder the inclusive culture Rogers Park is working towards. To help mitigate this, co-teaching classes were cut and ELL students were placed randomly within core classes. This would allow ELL and non-ELL students the chance to work together and collaborate in an academic setting.

Venture

To ensure content teachers had great skills and confidence to support their ELL students' language needs, the district had all teachers SIOP trained. SIOP (Sheltered Instruction Observation Protocol) is focused on thoughtfully implementing language supports to facilitate content and language learning. Danbury had their full time middle school SIOP coach lead the training sessions. As a school, we were taught about specific language supports to use with ELLs, as well as bringing in current content to brainstorm modifications with other science teachers. This training was focused on whole class supports and began to break down how to modify for different levels of ELLs so as to appropriately challenge them in both English and science.

While our SIOP coach supplied numerous opportunities for learning and one-on-one coaching, many science teachers struggle to create lessons that are rigorous for all students, but not limiting because of language. One main problem is time demands to develop modifications. With all science teachers teaching every level of ELL students, it takes more time and energy to create and implement modifications for each lesson. This increased demand for high quality and quantity modifications has put an increased strain on science teachers during preparation and class time. An added difficulty is that me and the other science teachers are no longer working with a language support co-teacher. This translates into all the science teacher working every day with students' language input and output — without having readily peer available to discuss student specific challenges and overall successes. The lack of connection to the ESL department has made the once holistic learning experience for the students and core teachers a separate and isolating.

This lack of cohesiveness is also doing a disservice to our LTEL students. Without teachers having the time to discuss specific language goals, LTELs are not receiving assignments in science that consistently addressing the gaps in English fluency and development. LTELs may continue to struggle with reading and writing, impacting their ability to communicate their understanding of science to their peers. I would like to offer the following questions to the crossroads attendees;

My Venture is to begin helping to create a professional community among science and ESL teachers that supports providing equitable science education opportunities to Long-Term English Language Learners. I'm only a second-year teacher and I hope others have ideas to help me along:

A. How do I create a community between science and ESL teachers to provide an equitable opportunity for science education to LTEL Students?

B. Additionally, how do I achieve this with no current meeting or contracted time to discuss students, content, or language?

C. What would be reasonable to attempt in the short-term this year – and what might we try to put in place for the long-term?

Accessing Engaging Science Teaching for Deaf and Hard of Hearing Students

Patrick Enderle, *Georgia State University*

Vexation

Deaf and Hard of Hearing (DHH) students comprise a small segment of students, but the challenges they face reflect similar ones faced by many students from minoritized groups. Indeed, many DHH students intersectionally belong to other groups, compounding their challenges with equity. DHH students experience science education in rather different ways than most students, due to the fact that, most often, they must communicate their ideas through two different languages. Although written communication draws on these students' ability to communicate through English (in the United States), many DHH students communicate verbally through American Sign Language (ASL). Translation across these two languages are fraught with challenges for ASL speakers, often due to the rather different grammatical structure of the two languages, as well as the fact that the volume and complexity of terms available in ASL does not necessarily align well with English counterparts, nor the more expansive English lexicon. Compounding this issue is the fact that when presented with challenges across the two languages, many DHH communities develop their own signs to communicate certain ideas, creating regional dialects not be shared across larger populations (Frishberg, 1975).

Further challenges arise as educators work to enhance teaching and learning by emphasizing the science and engineering practices (SEPs) and helping students understand science as a cultural way of knowing while also introducing a wealth of domain specific terminology (Enderle et al., 2019). Yet, work I have done with colleagues demonstrates there are not adequate ASL resources to support students' understanding and ability to communicate about these aspects of science (Cohen et al., 2019; Enderle et al., 2019). Many of the ASL resources available for science focus mostly on signs about particular concepts, such as photosynthesis or atoms. While valuable, working to ensure equitable access to engaging and innovative science learning experiences must also include: 1) the expanded development of ASL resources that support current visions for science education, including the SEPs, and 2) ways to support science teachers of DHH students in selecting and/or developing their own resources. Unfortunately, these two needs face existing systemic barriers to high quality science education for DHH students.

An ongoing debate exists among educators who work with DHH students concerning what broad learning goals should be for these learners. Some educators feel that DHH students should be taught in ways that result in them becoming orally proficient in speaking English, coupled with hearing assistance facilitated through technology like cochlear implants (Schick, 2011). In contrast, other scholars who work with DHH students feel that learners should be afforded access to enriching educational experiences in the register they feel most comfortable with, which for many would entail use of ASL to communicate (Grosjean, 2010). As a result of this ongoing tension, a spectrum of educational opportunities exists for DHH students. Some schools, specifically designed to work with DHH learners, work from a more 'oralist' orientation, emphasizing the role of spoken English throughout their curriculum and instruction. Such an intense focus can even lead to some schools forgoing the use of ASL for any communication, rather relying on a similar but distinct form of signing referred to as Manually Coded English (MSE). Alternately, several schools for DHH learners more strongly emphasize the value of ASL for their students' learning.

However, a majority of DHH learners do not attend these more specialized schools, instead attending mainstream K12 schools. In these mainstream contexts, many students are placed in regular classrooms alongside hearing peers, where the DHH students are often the only one or two students with different hearing abilities. In other mainstream schools, DHH learners are placed in a 'self-contained' classroom with other DHH students, where instruction in multiple disciplines occurs. Within mainstream classrooms, teachers often rely on support from interpreters. Yet, another systemic issue develops from this collaboration, as the standards used to certify educational interpreters allow for interpreters to accurately convey only about 50% of the actual classroom discourse for them to be considered proficient to work in classrooms. In such mainstream situations, a deaf student who uses ASL is very likely to have interpreters who can only provide a recounting of about half of the discussion, given the great potential that they are not well versed in signs that do exist for science classrooms.

Across these different learning environments, an emphasis on literacy dominates many considerations for instruction for DHH students. As a result, the quality of science instruction may be restricted due to the primary focus of educational experiences being more centered on improving students' verbal and writing proficiencies, rather than their conceptual and practical understandings within other disciplines. Many teachers working in such schools typically specialize in literacy and language education in their preparation, rather than having rich experience in the disciplinary content areas they are assigned to teach, including science (Luft, 2008). Such preparation does not automatically preclude these teachers from offering engaging science instruction, but it does limit their ability to appreciate the depth and nuance of communicating with and about scientific concepts and practices. This reality exists although scholarship in deaf education affirms that inquiry oriented instruction focused on students engaging in the practices of science to develop understanding about interesting phenomena is the most appropriate way of teaching science to DHH students as well (Lang, Hupper, Monte, Brown, Babb, & Scheifele, 2007). Although language may present challenges in creating such experiences for DHH learners, science educators also assert that language learning is enhanced when coupled with more engaging, SEP focused experiences (Lee, Quinn, & Valdez, 2013). Thus, my vexation stems from the variety of educational contexts that exist for DHH learners. I'm struggling to understand how to best support these students, and their teachers in science? How can we provide rich and rigorous science learning experiences?

Venture

Regarding ASL resources for communicating about the SEPs and other aspects of science, my colleagues and I have already identified areas where direct development of a lexicon of signs could be useful. However, as a hearing person, I do not want to base such work only on the scant but more formal, published resources. Rather, I would like to first explore what signs and resources DHH students already use to communicate. My colleagues and I are fortunate in that we also collaborate on providing a summer STEM camp experience for DHH students. We have designed experiences that will engage students in several SEPs, including arguing from evidence, developing and using models, designing investigations, and constructing explanations. I would like to observe (through video recording) the students' discussions as they participate in these activities to determine the kinds of signs they use to communicate ideas about evidence, reasoning, variables, etc. By exploring the ways DHH learners naturally communicate about these ideas, we could then potentially develop a set of lexical resources that draws from the students own linguistic activities. Other work that could extend from this investigation could involve studying the ASL language used by the students to determine connection points to existing science ASL resources to determine processes from which further signs could be developed based off of students' existing lexicon. With these ideas, I am interested to understand ways of investigating the unique linguistic resources of particular communities. How can I, as a hearing person, most effectively AND appropriately make sense of the linguistic resources DHH students employ in their existing conversations around science? How do we balance the tension inherent in such work stemming from the privileged position of the researcher from differing (and what some would identify as hegemonic) cultural institutions while still maintaining a focus on equitable treatment of the communities they work with?

With respect to supporting science teachers of DHH students, again, I am interested in first surveying such teachers to determine how they make sense of the SEPs and inquiry oriented instruction, and what ASL resources they may use to communicate about them. Findings from this work could also be used in the development of extended lexical resources described earlier. Another element I would like to explore with these teachers is their perspectives on the types of support they would prefer and would find useful. Preliminary work done with a science teacher in a school for DHH learners found that the teacher, who was not prepared as a science teacher, had limited interest in resources that were too intricate to use or required too much effort (Cohen, n.d.). Determining such preferences across a broader group of teachers who work with DHH students will be valuable in orienting ongoing work to support their science teaching. Again, this baseline work should help to inform future development of professional learning experiences and science ASL resources aimed at supporting these teachers. Further, based upon these efforts, resources could be developed for teacher preparation programs to support pre-service science teachers' learning about ways to enhance the learning experience for DHH students that may be present in their future classrooms. Also, working with colleagues in Deaf Education, materials, courses, and professional development experiences could be developed to support teachers in those preparation programs and specialized schools. One challenge I foresee with such efforts involves the array of contexts in which science teachers of DHH students work. I would be interested to hear from others who have experiences in working to support teachers across several unique environments. How should resources developed to support science teachers be adapted for the varied array of contexts described previously? What 'rules of thumb' or established design principles exist that could inform the work I describe above to ensure that resources and experiences my colleagues and I develop out of this work provide the most support possible for the broadest array of teachers?

Gaining Voice to Give Voice to STEM Explorers

Mark Enfield, *Elon University*

Vexation

From my perspective, equity in STEM education is confronted by two kinds of interconnected vexations. First, how can we address inequities in STEM learning? Second, how can individuals and communities lead in confronting the challenges of inequity in STEM learning? These broad questions serve as a framework for what follows. Implicit is the assumption that addressing equity in STEM relates to broader issues of equity and social justice. For now, let me focus on the more specific questions.

Maybe it happened by accident or maybe my tacit understandings led me to this position, but I think an important challenge to equity involves individuals' access to STEM enrichment experiences. Lareau (1989) offers an explanation of how the families from different socioeconomic backgrounds engage with schools. In particular she describes how families advocate differently for their children's needs in school. Extending on this, we know that there are differences in the kinds of enrichment available and afforded to children across socioeconomic and sociocultural spectra. Providing access to STEM enrichment experiences can be one way to impact inequity within STEM. I am not alone in thinking about this issue; several scholars have advocated for and engaged in research on STEM programming in informal settings and the role of equity in those opportunities in making STEM accessible (Barton & Berchini, 2013; Barton et al., 1999; Barton & Tan, 2010; Rahm, 2012). When I connect the praxis-driven research on informal STEM with Lareau's ideas, I think about ensuring equitable access to high-quality STEM enrichment experiences.

While I had some ideas about equity in STEM rooted in my dissertation, my recent thinking begins about eight or nine years ago. I was becoming restless with not teaching science, and not having a teaching schedule that allowed me to work in a school, so I created an after-school STEM program at a local public housing authority. I continued leading the after-school program for four years and I still wonder who learned more. My experiences with that program was the background for many of my Crossroads conference writings and led me to write a reflexive book (Enfield, 2018). During those years I was witnessed how limited access to science enrichment experiences created a form of structural violence – children without means or access to enrichment experiences are left with limited to no STEM learning opportunities since the limited STEM learning in school is primarily rote, teacher-directed, and vocabulary-heavy instruction.

A few years ago, I offered another enrichment program to recent immigrants learning English. Planning and leading hands-on, inquiry-driven STEM lessons to ELL students required thinking about vocabulary acquisition and how language knowledge and use interact. This experience caused me to reflect on how STEM learning can mediate access; it is not just something to have access to. While I began my journey from a somewhat provincial perspective on access, my thinking has evolved that our discussions around STEM focus too heavily on access to STEM when we should also be considering how STEM can afford access. This perspective reminds me of Wortham's (2004) discussion of 'ontological learning' in which learning (in this case STEM learning) impacts changes in knowledge and also changes in the self.

The related vexation about how individuals and communities can lead in confronting challenges of inequity is probably more vexing for me. I am often wondering what counts as leadership, whether a leader need to have a position or title, and how different forms of leadership result in different outcomes? These questions are personal since their answers have implications for whether I will stand for promotion. At my institution, leadership is an important dimension of the portfolio for promotion to full professor which invites me to consider different meanings and different spheres of leadership. Having reviewed files for promotion, I am concerned that my leadership will not 'measure up' yet I recognize that leadership as important; so one vexation is about how to get my leadership acknowledged.

I lead through action, quietly doing, but not always seeking the attention. Recently, I have been vexed a little about my own positionality. I find myself thinking about my role in advocating for equity and STEM learning. While my experiential knowledge of marginalization is limited and by all accounts should be a 'poster child' for canonical STEM education, I recognize a few things. I am troubled by the equity of communicative practices in STEM. As others have argued, certain Discourses are privileged (Brown, Reveles, & Kelly, 2005; Lemke, 1990) and I feel this connects with how we frame the epistemic practices of science (Enfield, Smith, & Gruber, 2008; Sandoval, 2004). How can I lead in making space for other communicative practices in STEM? How can I offer alternative opportunities though informal learning for multi-modal of expression in STEM? What is my leadership role in transforming who and what counts in STEM while also celebrating learners' wonders? As I consider what I know and what I am able to do, I wonder who is my audience, who am I leading, and what do I hope they will gain from my leadership?

Venture

Someone might ask, "so what are you doing?" I decided to build on what I know in an attempt to improve STEM learning for students in the community around my university who might not have the opportunities to engage in STEM enrichment experiences. When I first wrote my vexation and venture, I was in the middle of recruiting highly-engaged, intellectually-curious middle school students for a week-long STEM summer program. I launched this venture as a response to some of the vexations I previously described. I will say briefly that the camp was an unmitigated success. Participants begged for an overnight version, parents and I cried at the closing ceremony, and the parents thanked me repeatedly both for the opportunity and including things like meals and busing. Now, the program is complete, I bask in the glow of how it became even more than I had dreamed of. I am wrapping up final reports to funding agencies, and I am desperately looking for more funds to carry us through another summer.

This venture was important because STEM enrichment opportunities for students in my county are limited. The university runs a very successful college access program for high school students, but there are fewer opportunities for middle school students. Moreover, the available programming seems to fall into two types (with the exception of the college access program) that include either programs for gifted students (a program that not all students can access) or remediation programs for struggling students. In my informal elementary programs, I met so many students who might be deemed 'average,' but who were enthusiastic or really engaged in science. I also met students who were fantastic thinkers, but who could not afford meals or transportation to other enrichment programs. I wanted to create opportunities for these students to be scientific thinkers, explorers, wonderers, and communicators.

Second, I wanted to shift the discourse and communicative patterns of these experiences. I wanted STEM and STEM learning to be celebrated. Summer programs often have big performances at the end, but this is not something I have experienced in STEM camps. Furthermore, I wanted to disrupt the actual mode of communication and embrace digital technology. Therefore, the program involved what I call multi-media authoring in which communicators used digital tools to express their thoughts, wonders, and explanations using multimedia. These were publicly displayed on the final day of the program. For someone who rarely speaks in meetings, this is a big venture for me!

Taking on this project, I have found a voice and I have noticed that I have become more willing to use my voice. I have talked with people about the summer camp and have been sharing my ideas in other settings. As I plan to share at Crossroads, I will be anxious to share more about the outcome, but eager to hear feedback and thoughts about my next step. At a basic level, what recommendations are there for promoting and supporting the program? Moving beyond that, an expanded venture will be to invite student-generated wonders that are pursued with support through the spring and culminating with a week-long program. This model is not ready for prime-time, but I am curious to know whether Crossrodians believe this is an effective approach to STEM equity. What advice do they have for a long-term program (running April-July)? What ideas do others have about making it sustainable? Finally, what suggestions do people have about advocating this as constituting leadership in STEM equity?

Reading is Between the Lines

Rachael Gabriel, *University of Connecticut*

Vexation

In order for instructional leaders to feel empowered to lead, they have to know what they're leading towards. Too often, broad themes like equity, excellence or effectiveness are unsupported by specific understandings of the key ingredients and processes for producing these things. This hollows out promises for leadership towards rigor, engagement and achievement and slowly drains confidence and sincerity from many well-meaning instructional leaders who bring solid pedagogical knowledge to their work.

Though leaders may have been able to create connections between their everyday interactions and the larger goals they aimed to pursue within their own classrooms, it is difficult to generate the same level of specificity when working with teachers across grades, subject areas and departments. I think that focusing on literacy processes (reading, writing, representing, communicating) could be a powerful lingua franca for getting to the heart of teaching and learning interactions, even in areas where a leader may lack expertise or native-like fluency (e.g., a former biology teacher observing a mathematics or shop class). I also believe that teachers who orient to their work as developing literacies within a discipline are more likely to make explicit some of the implicit assumptions, conventions and ways of using language that make some students feel like insiders who are competent, and others feel as though they must be outsiders and/or incompetent. Too often, this translates to students saying they just aren't a ___ person (e.g. math, science, etc.) when they might be if they had experienced more ease and success when engaging with texts produced and used in these settings.

I am essentially arguing for an orientation towards ***disciplinary literacies*** (DL) to inform the coaching and feedback leaders provide to teachers, and the ways that educators understand and strategize for instructional strength. This requires using a broad definition of "text" as any representation of knowledge whether written, visual, auditory or kinesthetic/tactile. In other words printed documents count, but so does a conductor's beat pattern in band class, an engine's diagnosable sounds in auto shop, a color or volume change within a beaker in science, etc. If we need to "read" them to make meaning from them, we need to teach students how: what to look for (decode), how to monitor changes over time (fluency) or self-monitor for errors (metacognition), how to compare or connect them with other texts (comprehension), etc. I argue that engagement with authentic ways of using texts to generate, share and critique ideas will increase student engagement and achievement both in the discipline and in reading/writing in general because of the meaningful exposure and practice with recognition and comprehension in a wide range of forms. This has the potential to invite more students into more meaningful engagement in STEM and other areas, and to provide leaders with a powerful way to engage teachers in supporting higher intellectual engagement and achievement.

Specifically, a DL orientation would lead educators to ask themselves a set of questions related to the representation of knowledge, and make shifts in their instruction in response to the answers:

1) What texts are used by people who engage with this **content outside of school settings**?
   a) How can students approximate or emulate their processes, uses and reasons for using such texts?

2) How are students engaging with the texts that are most central to this lesson?
   a) What do students need to know to move towards more explicit understanding, engagement and independence?

I argue that this set of linked questions can be used to think and talk about the very crux of the teaching/learning interactions educators are designing and implementing. However, there is no evidence (yet) that they will work.

Venture

I am often approached by leaders who want to understand literacy instruction for its own sake and/or for the sake of supporting engagement and achievement in STEM areas. However, they are usually doing so as a defense against pressure from outside sources: "My board says our reading scores need to improve, so I'm contacting you," "My teachers say the middle school doesn't teach reading well enough, so I'm contacting you." My hunch is that a convincing argument needs to include some compelling evidence that discipline-specific literacy instruction is a) doable, and b) uniquely supportive of engagement and achievement in each discipline. However, I am struggling with designing a study that demonstrates the kinds of dynamic growth I imagine is possible with such an approach.

I have tried:

- Outlining the theoretical argument of a focus on explicit teaching for text use across content areas.
- Measuring pre- and in-service teacher growth in learning the concepts associated with a DL orientation in my DL course. This isn't terribly convincing because it is so divorced from practice. They can integrate it into their plans, which demonstrates some form of feasibility, but a two-week intensive or month-long online course is not long enough to do any meaningful inquiry cycles related to application.
- Gathering principals' self-reported changes when engaging with these questions in post-observation debrief conversations, which again shows that it is feasible, and even that there was some degree of satisfaction with this approach, but does not begin to address impact.
- Designing a study to measure the impact of DL strategies on a range of student outcomes, but this requires developing tools to measure content, literacy and engagement that can be used to show growth over small periods of time (between observations which occur several times per year) and are flexible enough/easy enough to create/replicate that they can be used across content areas.

If it were possible to demonstrate the impact of a DL approach to observations and feedback, leaders would be able to engage in fruitful, relevant conversations focused on instructional quality, even for content where they lack direct experience or expertise. This could not only empower teachers to create more accessible opportunities for engagement in disciplinary learning, but may also support students' overall literacy development because of the emphasis on concept development, meaning making and analysis.

Wrestling with Privilege in an Age of Testing

Andrew Gilbert, *George Mason University*

Vexation

As I left the Evergreen Woods School parking lot to journey back to campus, a wave of sadness and frustration washed over me. This caught me off guard as I had just spent the last three hours watching in awe as every child in the school took part in the "Muddy Monday" afternoon that was filled with intentional approaches to wonder. I followed a grade four class through three group stations across the school property that included a forested parcel of land, a school garden and dry pond drainage area that was constructed a year prior as a means to slow runoff and grow native plants on school grounds. In the forest station, children worked in teams searching for areas that could become an excellent site for building a future shelter. This included gathering evidence, making claims and defending those ideas. In the school garden, the group replanted tomatoes that they had germinated from seeds and now needed to be transplanted to larger containers. The final station was the drainage pond, and children wandered the edges observing the native perennials and were asked to sketch the signs of new growth of one or two of the plants. These stations were filled with astoundingly insightful children who were curious and filled with wonder that was acknowledged by their teachers as a valuable way of engaging in content, particularly with their outdoor sustainability program. These are exactly the kinds of experiences my research has been working to bring to teachers and their students (Gilbert & Byers, 2017). So why was I struggling with my own reactions to these experiences and feeling frustrated? The tuition at *Evergreen Woods School* is over $12,000 per year and well beyond the reach of so many families.

The experiences at Evergreen Woods stand in stark contrast to typical experiences in public schools around the country, particularly those schools that are at or below state mandated score levels on end of year tests. The typical approach is to increase remediation founded in deficit-oriented approaches that do not take into account the assets and abilities of culturally, linguistically and economically diverse children (Iannacci, 2018). This strikes at the core of STEM equity since we are actively creating different trajectories for students of varying economic means. Money seemingly can buy children the *privilege* to wonder.

Ridgeview Elementary, just a short drive from Evergreen Woods, is a truly diverse public school with 900 pupils that includes a broad array of languages, ethnicities and economic levels. They have a committed and professional staff that cares about students' well-being. But a vastly different reality is at play in Ridgeview. Namely, the looming end-of-year *Virginia Standards of Learning* test dominates the spring calendar at Ridgeview. Despite these realities, Ridgeview has an award winning STEAM program. The program includes a 'Green' STEAM after school club and a STEAM class that students attend every few weeks. The class itself works to bring in elements of outdoor engagement, wondering, gathering evidence and designing solutions to environmental problems. There are also several events throughout the year meant to engage the school community including family STEAM night, farmers market, and a trout release field trip for 5th and 6th grade students. However, all of these events come mainly from the efforts of one STEAM teacher trying to meet the needs of 900 children across the school.

In the simplest terms my vexation is how to bring engaging approaches to science related content to greater numbers of diverse public school children. The overarching goal is to remind diverse children that their STEM-related wonderings, observations and ideas are valuable. At the heart of this vexation lies a larger problem with diverse public schools; namely, any effort must be framed within increasing achievement on end of year state testing. This also raises difficult questions in terms of STEM leadership, should the tests be driving all of our efforts? Or as STEM leaders should we fight against tests that have been shown to be, at their worst, racist (Au, 2009)? If STEM leaders embrace a role of increasing test scores, does that validate the so-called value of those tests? I still struggle with this dilemma. My vexation continues if we frame success solely on increasing test scores, am I just reifying the ways in which schooling has continued to disempower diverse children? My pragmatist teacher instincts push me consider possible ways to operate within our current reality (while still fighting these legislative decisions in other contexts) to ask the more practical question: can an integrated "Green STEAM" (GS) approach help schools, children, teachers and future teachers navigate the terrain of testing while also bringing joyful wonder-infused pedagogy into diverse public school contexts?

Venture

Four years ago, I began working with Ridgeview and over time trusting relationships have developed across our institutional boundaries. Recently, while chatting with the Ridgeview Principal, he asked if George Mason University's (GMU) elementary education program could facilitate his commitment to bringing issues of sustainability and outdoor education to more classrooms across the school. My vision of STEM leadership is to facilitate Ridgeview's goals while also helping to create spaces for justice and equity to grow even in the face of testing regimes. As such, this venture seeks to make sense of wonder-infused pedagogical practices associated with outdoor education and sustainability principles (Sezen-Barrie, Miller-Rushing & Hufnagel, 2019) to investigate if it can impact diverse student interest and achievement. Our hypothesis is that the daily commitment to these principles will lower student stress, increase student interest and strengthen interconnectivity of content and should facilitate teachers' ability to integrate content. Ridgeview and GMU have recently been awarded a grant for $40,000 to carry out further development of the GS approach and its associated impact on the school community.

The first goal is to amplify the powerful practice of model teachers like Ridgeview's dynamic STEAM teacher. GMU will also offer an integrated STEM course for our pre-service teachers taught on site at Ridgeview, which will allow our future teachers to observe and participate in the STEAM lab and outdoor activities. These interns will then be placed with current teachers at Ridgeview for their yearlong internships. Secondly, we will offer the teachers who receive interns ongoing PD as part of a course titled "Green STEAM" for elementary educators. The grant will cover the cost of the course, which will count for roughly half of teachers' recertification points toward their license renewal. The class will include pedagogical methods, reflection, sharing sessions, and a professional learning community within the school. The principal will also include release days for the participating teachers to go on two outdoor experiential trips while asking teachers involved to commit to at least thirty minutes every day spent working on GS pedagogical tasks. The research team will investigate classroom practices of participating teachers as well as impact on teacher content understanding and visions of student abilities. Similarly, we will investigate student content understanding, interest in GS and track student performance on end of year testing. Ultimately, our social justice goals are about providing diverse children with dynamic and engaging ways of interacting with the world around them. This venture articulates continuing efforts to bring children powerful experiences steeped in wonder, noticing and joyous exploration. This represents an important avenue for research access, possibilities for designing stronger links between our programs, and creating more engaging daily pedagogy that focuses less on testing and more on STEAM experiences. Yet, my prior experiences suggest that there could be teacher resistance to these practices, or worse yet, teachers questioning if their children are capable of this more open-ended, critical thinking approach. I wish to learn from the Crossroads attendees for how they have engaged teachers in developing innovative pedagogy as a vehicle to create equitable experiences across STEM.

Questions to consider

1) In what ways have others facilitated teachers in reflecting on their own practices as opposed to framing efforts on 'fixing' children?
2) Does working to strengthen school achievement on testing send the message that the tests are unproblematic? Does this fit with a vision of equity or just reify the structures that have continually harmed diverse children?
3) How might *equity in STEM education leadership* be an avenue for facilitating teacher growth away from traditional pedagogical approaches, particularly those children struggling with poverty?
4) Are there other areas I may need to consider or blind spots that I may need to attend to as a part of this effort?

Using language to figure out scientific phenomena: Developing elementary science methods courses that address the linguistic rigor inherent to science practices

María González-Howard, *The University of Texas at Austin*

Vexation

Science practices are recognized as instrumental for supporting and enhancing students' experiences working alongside peers to co-construct knowledge around natural phenomena (NGSS Lead States, 2013; Osborne, 2014). Deeply engrained within this view of learning science are expanded notions of what scientific sensemaking looks like, and thus also expanded views of who can engage in science (Bang et al., 2017). For example, moving away from a prescribed method for doing science (i.e., carrying out "the scientific method") (Windschitl et al., 2008), science practices, like modeling and argumentation, capture and represent wide-ranging ways by which diverse communities make sense of scientific phenomena (Bang et al., 2017). Learning environments grounded in the science-as-practice approach support students' epistemic agency (Stroupe, 2014) and hold promise for addressing inequities in science education, especially for students from historically marginalized groups, such as emerging bilingual (EB) students[1] (Lee et al., 2014). In part, this is because supporting students in science practices requires teachers to attend more closely to what their students are saying and doing as they work together to develop and refine knowledge about the world (Bang et al., 2017).

Partaking in science practices as a means by which to "figure out" scientific phenomena (Reiser et al., 2017) requires rigorous and complex language use (Lee et al., 2013). For example, when engaging in oral argumentation students must employ various language functions (e.g., listening and speaking) in real time as they take in their peers' ideas, make sense of them in light of their own thinking, and respond in ways to further the groups' understanding (González-Howard et al., 2017). It is critical that teachers understand and address the language demands inherent to science practices given the unequal access and inadequate instruction that EB students have historically received in science (Hakuta et al., 2013; NASEM, 2018). However, most science teachers are unprepared to instruct EB students (NASEM, 2018), not having received training around the intersections of English language development and engagement in scientific sensemaking. Therefore, realizing the large changes in learning goals described in current reform documents (e.g., NGSS Lead States, 2013), depends on developing new teachers who have undergone training that forefronts what it means to teach and support students in doing science through science practices (Osborne, 2014), particularly in terms of the ways language is central to sensemaking (Lee et al., 2013).

Heavily influenced by past educational experiences in this country (both as an EB student, and then a middle school science teacher of mostly EB students) as well as my current faculty position at an institution located in a state with a large and growing number of EB students, I am personally drawn to this issue. I consider myself very fortunate to work in the space that I do; one of the many reasons being that my responsibilities encompass teaching elementary science methods, including one section of the course that is specifically designed for pre-service teachers seeking bilingual certification. I view teacher education programs, and courses such as the ones I teach, to be one way to address the complex situation I outlined earlier. As such, my goal is to develop an elementary science methods course that cultivates pre-service teachers' understandings of not only the science-as-practice approach (Osborne, 2014), but also the fundamental role that language plays in "figuring out" natural phenomena (Reiser et al., 2017) through engagement in practices.

Venture

In order to create a science methods course that addresses my vexation, I intend to carry out multiple iterations of design-based research (DBR) (The Design-Based Research Collective, 2003) to

[1] I intentionally use the term emerging bilingual (García, 2009), which is asset-based as it highlights students' multiple resources and abilities to speak language(s) in addition to English. I also use the term EB recognizing that it captures complex heterogeneity across many facets, such as prior schooling experience, languages spoken, and country of birth.

develop, implement and analyze various types of instructional materials. My goal is for these instructional materials – which will include a range of things, such as readings, class activities and assignments – to support pre-service teachers' learning and developing understandings around teaching science and practice, and the role of language in sensemaking. In addition to grounding the development of the instructional materials in recommendations from prior research on the matter, I would like to work with and learn from the experts themselves – exemplary elementary school teachers of EB students, who are authentically and successfully engaging their students in science practices.

This work will need to occur over many years, especially if done thoughtfully and rigorously. I recognize that the various components of it (i.e., learning from exemplary in-service teachers, and then translating the lessons learned from those classrooms into my elementary science methods courses) are heavily intertwined and will often occur simultaneously. For instance, while I am in the field examining what exemplary teachers do to support EB students' engaging in meaningful scientific sensemaking, I will also be incorporating prior observations of these teachers and their classrooms into the design of my methods course. There are a few aspects of this work that I am contemplating and would greatly appreciate feedback on: 1) how to operationalize and identify "exemplary teachers," and 2) developing means by which to gauge pre-service teachers' current understandings of science teaching and learning, including the role language plays in doing science.

1. ***Who are exemplary teachers?*** To learn what makes teachers exemplary, I intend to explore questions such as – What are their views on teaching science and language? What prior educational and/or life experiences shaped these views? How do they continually revise and grow in their own practices, particularly in terms of staying current with reform efforts? However, I first need to operationalize, and then identify, "exemplary teachers." Aside from logistical concerns (e.g., How many teachers, and across what grade level(s)? What if I cannot identify "enough" of these teachers?), I first need to operationalize "exemplary." Part of my dilemma is rooted in Texas not adapting or adopting the NGSS, which results in my struggle over what language to use to describe science practices. This brings up questions like, how can I talk about science practices without using this terminology? Another thing I am grappling with is– what does it mean to be an "exemplary teacher" and who decides? I know that I do not want this defined by students' scores on standardized exams, and that more importantly I do want to include multiple stakeholders (e.g., teachers, parents, administrators, students) in the process of identifying these teachers. I welcome ideas around what means I should use for this identification process (e.g., interviews, surveys, email solicitation for nominations) and what kinds of questions I should ask to identify these teachers?

2. ***What is the nature of pre-service teachers' current understandings of science learning and the role of language in doing science?*** Ideally, I want my methods course to shift the needle in pre-service teachers' thinking about what it means to do science, and how doing science intersects with language. I am currently wrestling with how to measure such growth? What means (e.g., surveys, individual or focus group interviews, reflections, lesson plans) will offer the best insight into their thinking and (hopefully) changes in their thinking after taking my course? Perhaps a combination of approaches would work best? I also like the idea of using videos, vignettes and/or classroom transcripts but worry those might result in responses that are too context-dependent (e.g., "In the video students did X, but that would not work in my practicum setting because Y.") Relatedly, I appreciate any recommendations for the types of prompts or questions I might use to elicit such information. I worry about swaying pre-service teachers' responses if I ask questions that are too pointed (e.g., What do you understand the role of language to be in learning and doing science?).

Factors Influencing the Persistence of African American Students in STEM Majors at a Predominantly White University

André M. Green, *The University of South Alabama*

Vexation

Within the past year, I along with two co-authors, published a paper in *Science Education* entitled Applying actor-network theory to identify factors contributing to non-persistence of African American students in STEM majors (Green, Brand, Glasson, 2019). The article explored the experiences of African American students who attended a predominantly white university and did not persist in their STEM major. The article provided insights about reasons many minority students leave these majors. The article also gave these students a voice so that more can understand to perhaps change some things in the environment of PWIs that would encourage more African American students to persist.

Sadly, many African American students at predominantly white institution who major in a STEM area do not persist. Green, Brand, and Glasson in 2019 state that:

> Identifying and understanding the factors that contribute to this phenomenon has been the focus of numerous research studies. The lack of success for African Americans in STEM programs at majority White enrollment campuses has been linked to inadequate high school preparation, ineffective retention programs, and the university environment. The stereotypic perception of African Americans as being mentally inferior and the experience of isolation and negative encounters with faculty and students have also been linked to the lack of success for African Americans in STEM majors. For these, and possibly other reasons, many talented African Americans who attend predominantly White universities, who pursue STEM majors are not persisting. (p. 3)

However, some African American students do persist as STEM majors at predominantly white institutions. These individuals have experiences that institutions might learn from to retain more African American students in STEM majors. In the paper reference above the students who do not persist in STEM areas were of good pedigree in terms of their academic background. In many instances this is the case the case. According to Maton, Hrabowski, and Schmitt (2000):

> African American students with respectable SAT scores who under-perform provide evidence that factor's other than pre-collegiate preparation and native ability work to depress minority achievement and persistence. These factors may include academic and cultural isolation, motivational and performance vulnerability in the face of negative stereotypes and low expectations for performance, peers not supportive of academic success, and perceived and actual discrimination. (p.630)

The problem is much deeper than a SAT score and cannot be explained away by using only quantitative data. In the study we performed, preliminary results indicated that the students who persisted were not that much different than those students who did not persist: their profiles were very similar. The question is what was it that was so different that made one group persist and another group not persist.

This is journey is a personal one for me as I am "in a way" one of those students who did not persist at a predominantly white institution in a STEM area. I say "in a way", because I hold two degrees in Chemistry from two outstanding Historically Black Institutions. However, my experiences at a predominantly White institution pursuing a PhD in chemistry mirror those of undergraduate minority students who do not persist in their STEM major.

Venture

The questions I want to answer or explore are:

a. How do African American students who persist in their major in STEM majors describe their experiences at a predominantly White institution?
b. What factors influenced the persistence of African American students within STEM majors at a predominantly White institution?
c. Were their experiences different than those African American students who did not persist?

My next step in this process is to analyze data I have already collected from African American students who persisted in their STEM major and graduated. I want to examine the experiences of those students who persisted against of those students who did not persist to see the similarities and differences between them. Perhaps by examining these experiences to see similarities and differences I can pinpoint what one group did wrong and what one group did right. My desire would be to assist students of color in these majors with a road map of how to persist and graduate in STEM majors at predominantly white institutions. In addition, perhaps something can be shared with universities so that they can be more assistance to African American students in STEM majors.

Overlapping Spheres of STEM, Social Justice, Socio-emotional Learning, and Self-Regulation?

Sumi Hagiwara, *Montclair State University*

Vexation

When the *No Child Left Behind Act of 2001* was passed, I remember announcing its significance to my graduate elementary STEM methods students, asserting that the future of science education was at stake. While the emphasis on language arts and mathematics is justifiable, I critiqued the policy for undermining access to knowledge and skills in subject areas such as science, social studies, art, and physical education. Not only would the instructional foci shift away from these subjects, it would compound the distance between students and teachers, shifting instruction from teaching the whole child to teaching and testing ELA and math. By increasing instructional time on two subject areas, balanced instruction is compromised, along with vicarious opportunities to cultivate essential socioemotional learning (SEL) early on (Greenberg, Weissberg, O'Brien, Zins, Fredericks, Resnik, & Elias, 2003).

When students have positive attitudes and understanding of self in relation to others, they are more likely to make productive and intentional decisions (Elias, 2009; Snyder, 2014). Students' emotions affect how and what they learn, and caring relationships provide a foundation for deep, lasting learning (Elias, Zins, Weissberg, et al., 2003). In the absence of SEL development and science/STEM education as part of a balanced curriculum, what impact might it have on under-represented students in STEM? In what ways is the current agenda for STEM education addressing content knowledge and 21st Century Skills, more importantly, fostering the development of enduring life-long skills that students take with them across grade levels and throughout their life experiences, skills such as self-awareness, social awareness, self-management, and organization, responsible decision making and relationship management. These five domains constitute what the Collaborative for Academic, Social, and Emotional Learning (CASEL), identified as socioemotional learning (SEL).

From the cognitive science perspective, Park, Williams, Hernandez, Agocha, Carney, DePetric, and Lee (2019) examined the success of under-represented students in STEM during their first year in college. Factors that contributed to their success and persistence in STEM included self-regulation. The domains of self-regulation that impact under-represented student success included cognitive reappraisal, positive reframing, active coping, and social support. The domains identified by Park et. al. share overlapping spheres of influence with literature in SEL, grit and perseverance (Duckworth et al., 2007; Ray et al, 2010; Snyder, 2014), suggesting that by triangulating SEL, STEM engagement, and self-regulation, the STEM education community can identify instructional strategies that allow students to confront and overcome challenges associated with becoming a STEMist.

I approach this vexation through the lens of social justice and equity in STEM by exploring a population often marginalized in STEM discourse – students in early childhood settings (preschool through grade 3), particularly those in underserved communities. SEL instruction undergirds early childhood education when children inherently develop self-awareness, social awareness, self-management, organization, responsible decision making and relationship management. However, STEM education and initiatives is limited in early childhood. According to McClure, Guernsey, Clements, Bales, Nichols, Kendall-Taylor & Levine (2017) report *STEM Starts Early*, young children are not studied as often as older children in STEM. Funding for STEM research and exposure to STEM disciplines favors upper grade levels where subject area is emphasized. Even at the lower grades, STEM is distributed differently among early childhood and elementary settings. In preschool, children are exposed to science and math with limited or no exposure to technology and engineering. An emphasis on technology and engineering practices becomes more prominent as a child progresses through upper elementary grades. What are the implications of not providing full exposure to all STEM disciplines to young learners? Why not re-examine early childhood curricula to imagine early childhood education that exposes young children to SEL and STEM habits of mind that can allow them to succeed in STEM later in life?

Venture

The Venture that I have been contemplating is relevant to my work as a STEM methods course coordinator and instructor, and as a recently appointed chair for a newly formed department in my college, the Department of Teaching and Learning in the College of Education and Human Services. As a department that includes early childhood, elementary, and secondary teacher certification programs, I am challenged to shift my early childhood and elementary education foci on equity in STEM education to include all certification areas and support P-12 STEM teacher development. My aim is to identify ways in which STEM education can prepare future teachers with the pedagogical understanding of inquiry-based, project-based STEM learning that also intentionally prepares them with the knowledge, skills, and habits of mind to support socio-emotional learning in students across grade levels. ***How might these orientations be integrated into a STEM methods course and teacher preparation program as transdisciplinary rather than siloed areas of study?***

As an early childhood and elementary STEM educator/teacher educator, I have observed students begin the semester with the misconception that STEM and SEL are disconnected. Often, students understanding of STEM instruction is that it must be activity-based, hands-on and "fun". I encourage my students to critique this belief by reflecting on sounds instructional design, informed by learning outcomes as indicated by the standards (content and skills) and what is developmentally appropriate and essential for children to learn (SEL). The Venture that I have been exploring is the prevalence of STEM and SEL as intersected practices across grade levels and the challenges and questions that arise.

My perspective and practices have been to cultivate STEM and SEL with a focus on developing a sense of agency in young children. This is accomplished through thematic instruction that incorporates children's literature about change agents. Examples include books about Wangari Maathai cultivating community activism by planting trees and supporting agriculture to benefit her community, Claudette Colvin resisting injustice and claiming a sense of agency on a bus ride in Montgomery, and Mahatma Gandhi protecting his identity and heritage through The Salt March and demonstrating patience to weave cloth for his own clothing. Instructional objectives include an analysis of the qualities that each change agent possesses and how STEM and art emerge from each story.

The Venture that I embark upon is critical reflection of my approach to thinking about a trajectory of STEM education from early childhood to secondary education. Questions that guide my Venture are: Where is the place of STEM with SEL in the trajectory of education from early childhood through secondary education? How would STEM education reform that brings SEL with STEM into the forefront of early childhood through secondary education impact the student population entering STEM fields? How would including SEL into secondary STEM education be received content specialists? What perspectives might I need to consider in depth to legitimize the claim that an intersection of STEM, SEL and change agent can synergistically enhance learning in each? These questions, among others inform my current position as an early childhood and elementary STEM educator, and pose possibilities on how to imagine the trajectory of STEM and SEL into secondary education for course and program development for the department.

Supporting Equitable Elementary Science Teaching through Partnerships

Christa Haverly, *Northwestern University*

Vexation

In an effort to support three elementary teachers' equitable science teaching, I partnered with them for seven weeks each. As a research partner, I felt well-prepared to co-design tools with each teacher to support their equitable pedagogy. However, I felt under-prepared to co-design tools or engage in discourse to support other aspects of their equitable science teaching, including curriculum design and fostering anti-oppressive relationships with students. This became particularly problematic as one teacher in particular (who is White) expressed racist viewpoints about her students and their community with an assumption that as a White person, my viewpoints would align with hers. I felt compelled in these partnerships to move beyond a focus on pedagogy, but I felt underprepared to know where to start or how far to push. In this section on my vexation, I begin by defining what I mean by equitable science teaching. I then briefly describe my vexations, linking them to related systems-level challenges.

I define equitable science teaching more broadly than access to rigorous science learning opportunities, though certainly this presents its own challenge at the elementary level (Blank, 2013). Equitable science teaching orchestrates learning opportunities for students which meaningfully leverage students' funds of knowledge in the classroom (González & Moll, 2002) and expand what counts as science knowledge and participation in schools, such as in work on heterogeneity by Rosebery, Ogonowski, DiSchino, and Warren (2010). Equitable science teaching and learning work to transformatively de-settle inequitable power hierarchies (Bang, Warren, Rosebery, & Medin, 2013). The focus of my vexation is on supporting teachers' equitable science teaching through partnerships.

I co-designed a first-grade science unit with one of my partner teachers. Curriculum design prescribes a sequence of learning activities to promote student learning (Davis & Krajcik, 2005). Though classroom teachers may be best prepared to design equitable science learning activities based on their knowledge of their students' science sense-making resources, this effort must be exerted on top of an already over-burdened workload for elementary teachers (Johnson et al., 2005). When designed by universities, publishing companies, or even teams of teachers at the district level, these activities are de-contextualized to individual learners in classrooms, thus limiting opportunities towards expansive or transformative science teaching and learning. The curriculum co-design work I did with my teacher partner took an incredible amount of time, and as a result, is not a sustainable model for engaging in this kind of work. How can university researchers, then, support elementary teachers with equitable curriculum design—in other words, curriculum which leverages students' funds of knowledge and broadens science participation in response to students' varied resources for knowing and doing science?

In my partnership work with two of my teachers, I observed them engaging in oppressive relationships with (at least) some of their students. Anti-oppressive relationships are a key component of equitable teaching and learning, though they are described more frequently by multicultural educators (i.e., Milner, 2010) than science educators. However, it stands to reason that students in science classrooms benefit from anti-oppressive relationships which invite them to take risks with their ideas and grapple with uncertainty as they work to make sense of science phenomena (Manz, 2015). Building relationships with students is a familiar priority to every elementary teacher I have known over my 15-year career as an elementary educator; however, in my aforementioned research partnerships with my three teachers, I noted that two of the teachers fostered oppressive relationships with students but *did not recognize them as such*. In my efforts to work with them on their equitable science teaching, the need to additionally address their oppressive relationships with students presented itself, and I was uncertain what tools, frameworks, or discourse moves might be best leveraged to engage in these conversations. Their relationships appeared to be informed by deeper racist worldviews, which surfaced differently in conversations with each teacher, but which also commanded my attention and left me unsure how best to engage. Fundamentally, I wonder if researchers and educators can support equitable science teaching without also attending to teachers' relationships with their students and their worldviews.

Venture

***Curriculum*.** To support teachers' curriculum design, I have tried two things so far in my partnerships with two of my teachers. One strategy I utilized was to debrief with teachers after their science lessons. In those debriefs, we were able to make curricular decisions which were responsive to students' sense-making. For example, after students constructed their bar graphs with data, my teacher-partner's plan was to have students analyze their data and make claims in her next science lesson. However, students engaged in interesting sense-making conversations about the actual construction of the bar graphs. So, on my suggestion, my teacher-partner adjusted her plans for the next science lesson to engage students in further sense-making about bar graphs, their construction, their audiences, etc. This kind of curriculum design was similar to that promoted by Hammer, Goldberg, and Fargason (2012) wherein the curriculum is constructed, step-by-step, in response to students' science ideas. However, this style of curriculum design requires significant time and energy on the part of the teacher to be continuously flexible with their instructional plans from day to day while still maintaining coherence across lessons.

The other strategy I utilized was to co-design a tool with one teacher-partner which attempted to merge a David Hammer approach (such as above) which more or less followed students' sense-making with an inquiry approach based on the Experiences-Patterns-Explanations model proposed by Gunckel (2010). This was an attempt to provide teachers with more scaffolding (via the inquiry model) for designing curriculum, while still being responsive to students' sense-making ideas and resources. However, this approach continued to place a large time demand on the teacher to construct science curriculum, in addition to the challenge related to teachers' content knowledge and confidence in selecting anchoring phenomena for students to investigate.

Considering that both of the above strategies proved challenging for individual teachers and are likely not sustainable, it begs the question of what else can be done to support teachers with equitable elementary science curriculum. One university-based curriculum project I work on is experimenting with a "choose your own adventure" component which supports teachers in making decisions about what to teach based on students' science ideas (Richards, Bonomo, Thompson, & Haverly, 2019). Another university-based curriculum project I work on is intentionally building in opportunities for students to engage with multicultural texts (for example, *In the Garden with Dr. Carver*). Multicultural texts are not enough to move towards expansive science learning for students, but to the extent that we are modifying the content of the curriculum to move beyond mainstream notions of science participators as White and male, we are making some progress. Additionally, both curricula use educative features (Davis & Krajcik, 2005) to support teachers in their equitable use of the curriculum.

What else can be done to support elementary teachers with equitable science curriculum? How else should we be imagining the curriculum design process to support equitable science teaching and learning? Does equitable science teaching require abandoning the NGSS standards or merely expanding on them? And so on.

***Relationships*.** One question I hope to prioritize in my work is to improve my ability to support teachers in building anti-oppressive relationships with students and to engage teachers in difficult and critical conversations about race and racism. In my partnerships, I engaged in discourse which attempted to re-frame teachers' ways of engaging with or talking about individual students. For example, when one teacher described her Mexican student as lazy, I re-framed the conversation to draw her attention to the excessive heat that day. As another example, after observing another teacher's unpredictable and public reprimands for classroom disruptions, I shared with her a resource which once helped me (*Teach like a Champion*). Both of these efforts were limited. The re-framing was too subtle, particularly compared with our focus on science teaching. But how far can I push before triggering her (and my own?) White fragility (DiAngelo, 2018)? The book (*TLAC*) was not written with equitable teaching as a guiding framework. I am curious to hear from Crossroads participants about discourse approaches for countering teachers' deficit (and racist) viewpoints of their students. I am also curious to learn of other texts which may be more useful resources for teachers, such as *Troublemakers* (Shalaby, 2017), which I more recently became familiar with. Though relationship-building and teachers' worldviews may seem tangential to science teaching and learning, I strongly believe it is equally important as curriculum and pedagogy when it comes to equity outcomes for students.

Justice in Science Education: How to Honor Student Epistemologies While Supporting 3-Dimensional Science Teaching

Kathryn Hayes, *California State University, East Bay*

Vexation

Science education has a problem on its hands. Although there is an established relationship between participation in authentic science learning and engagement and achievement in science, severe gaps in science education quality exist across U.S. classrooms (Morgan et al. 2016; Quinn and Cooc 2015). Despite the longstanding call to engage in equitable practices, race, gender, and economic status continue to be significant markers of the degree to which students have access to quality educational experiences (Bae et al 2018; Lee and Luykx 2005). In addition to differences in science instructional approaches, inequitable practices have been documented in terms of tracking and insufficient lab facilities, and curricula. Studies conducted in some districts also report funds and materials to be inadequate (Penuel et al., 2008), with teachers spending their own money on supplies (Dorph et al., 2011; Hayes & Trexler, 2016). In addition, in high poverty contexts teachers may have lower expectations of students, reducing their use of inquiry pedagogies and critical thinking activities (Duschl et al., 2007; Warburton & Torff, 2005). Likewise, teachers may engage in less inquiry because because class sizes are unwieldy, or because of a difficult or overwhelming organizational context (Lee & Houseal, 2003). The cumulative effect of this opportunity gap during students' primary and secondary years likely contributes to the significant drops in science interest and achievement documented among students underrepresented in STEM (Bae et al 2018; Saçkes et al. 2011). These issues of equity have long interested me and motivated my work, as a teacher, a provider of professional development, and as a researcher.

Recently, I and my colleagues in the Science Partnership have begun digging more deeply into this issue, moving beyond questions of equity to grapple with issues of justice. We have noted arguments in the literature regarding the epistemological injustices that may be present in the teaching of science. The discipline of science, as it is practiced in the United States and embedded in the latest rounds of standards, is greatly influenced by Western (European derived) perspectives and practices (Le & Matias, 2019). Although science as a worldview, a body of knowledge, and a set of practices has been informed by many different cultural and national groups over time, at this point many of our students do not see themselves in either the epistemology of science nor among the scientists themselves (Le & Matias, 2019). This leads to students and parents of our diverse communities feeling "othered" by the science education process (Calabrese Barton & Tobin, 2002).

The multifaceted issues described above lead to several problems of justice. 1) There is a need for justice in terms of access; access to science education itself, access to materials and labs, and access to excellent teaching. 2) There is a need for justice in terms of the expectations placed on students and the ways in which their participation and knowledge are valued. 3) There is a need for justice in terms of who has control over the nature, the epistemology, and the practices of science itself and how it is taught. At the Science Partnership (a partnership between a county office of education and a university providing professional development for teachers at 8 local districts), we grapple with what this means for teacher professional development (PD). We hope to support teachers in deepening their understanding and implementation of the Next Generation Science Standards and the pedagogical principles that underlie them, while simultaneously addressing these issues of justice. Yet we struggle to bring together constructivism and emancipatory education.

Venture

In our current work in the Science Partnership we are attempting to address issues of equity and justice through professional development of teachers and administrators across seven urban districts. We embedded goals for equity at both the systemic and instructional levels, founded on a two-pronged approach to justice (Fraser, 2006). The first approach, ***distributive justice***, is grounded in the understanding that justice requires the opportunity for participation in all aspects of social life, including education. In order to address this aspect of justice, the outcomes of our project include the goal that all elementary students would have access to robust, 3-dimensional science instruction. We particularly focus on access for underrepresented students, such as bilingual or special education students who are sometimes pulled out of regular instruction. In our professional learning sessions, we also foster access to science sensemaking within the classroom (Bae, et al., 2018). We ask teachers to consider who is engaging in discourse around scientific phenomenon, whether certain groups of students are left out of the conversation, and what scaffolds could be put in place to change dynamics that disrupt the voice of underrepresented students. Such access, it should be noted, merely reaches the level of equality; in order to have true equity, historically marginalized students should have even greater access to the most high-quality science education than their White, male peers (Rodriguez & Morrison, 2019).

The second aspect of justice is embedded in our SCOPP project is ***cultural justice***. Even if people are allowed participation in the economic and social structures that provide access to resources, their participation is not equitable if the institution does not recognize nor value their culture, language, or selves (Fraser, 2006). The lack of valuing minoritized students, girls, and emergent multi-lingual students in the context of science education is well documented (Le & Matias, 2019). Our project attempts to mitigate this through supporting teachers in recognizing student identities, assets, and cultural wealth in the context of science education. We model how to value language and home knowledge in professional development, and provide learning experiences to support teachers in shifting their conceptualization of students. One of these experiences is our student work analysis protocol, wherein teachers examine student work (hopefully a three-dimensional formative assessment) and generate a list of themes that illustrate the ways that students are conceptualizing science ideas. Early evidence demonstrates that participating in this process is moving teachers away from categorizing students in deficit ways (ELL, EIP), and towards understanding how students learn based on their prior knowledge and classroom experiences.

Although we are pleased with the results of our approach to equity us far, we have not found a way to address the third area of injustice, regarding the nature, epistemology, and practices of science itself and how it is taught. Although the framework for K-12 science education has made steps towards including equity and justice, it still embraces normative (rather than critical) scientific practices and pedagogies (NRC, 2013; Rodriguez & Morrison, 2019). How can we support teachers in developing space for students' "critical science agency?" (Sheth, 2019), in which students both engage in social transformation and develop a powerful identity as a scientific thinker, facilitated by a deep and rigorous understanding of content (Basu et al., 2009)? How can we engage in pedagogy that recognizes the social ramifications of science and scientific topics (in that the "benefits and risks of science are not equally distributed"; Sheth, 2019, p 51), while simultaneously exposing students to the nature of science and helping them grow skills within the scientific endeavor? In schools, such conversations are quite complex. Parents who do not see themselves, their culture, or their language in the science curriculum may nonetheless insist that the curriculum focus on transmission of science facts rather than culturally responsive or critical pedagogy (Osborne & Calabrese Barton, 2000). Moreover, purposefully questioning and critiquing the scientific approach to generating knowledge opens the door equally to conservative critique of scientifically informed understanding of issues such as climate change. How do we support teachers in learning and deeply internalizing the pedagogical principles that underlie three-dimensional instruction, while simultaneously fostering a justice-based pedagogy?

Inequitable STEM Trajectories and Goals: Seeking a platform of clarity

Adam Johnston, *Weber State University*

Vexation

At the end of the last academic year I met with a local science teacher (a former student of mine), his principal, and their school's career and guidance counselor. This all came to pass as their school and this teacher were applying to my department to teach an elementary physics course as a "concurrent enrollment" offering. That is, a student in high school in this course could receive both high school physics credit and a university credit that checks certain boxes and counts towards an associate's degree at our state's universities. I'd offered the meeting because I'd had to decline their request to teach this course, something that related to the credentials of the teacher and our department's relatively rigid requirements for being able to teach such a course. But, more important, I'd suggested the meeting as a way to offer suggestions about how to help them move forward. Their school, it turns out, has a new physical presence on our university campus, so there's potential for me to work closely with them.

Going into the meeting, my basic offering was meant to be helpful and forward-moving for the school and its high school students. Yet, their requests and ideals were also what they thought would be helpful and forward-moving for students. That is, we all had students in mind, first and foremost, as well as a sense for what we believe is a successful outcome for them as they approached the end of high school. The mismatch of our views concretized an issue that's bothered me in nebulous ways for some time, and is now what I want to face head-on.

For the part of this school, there is a mission and an official state charter for them to be "early college" with an emphasis on math, engineering, and sciences. For years, they have had their operations on one of Weber State's satellite campuses, and most recently they've expanded their offerings so that they have classes on our main campus as well. This reflects a partnership with Weber State in which the students have access to some university courses that they can take early in the morning or later in the afternoon, scheduled around their high school coursework. Additionally, they have other college credit opportunities, including AP and concurrent enrollment offerings. The school is marketed via its partnership with the university and its potential to offer university credit and even associate's degrees while a student is still in high school. The university benefits in some general public relations, but also most recently in a very concrete way as the state legislature funded a building on campus that will house both university programs and the early college high school. None of this, however, has been guided by faculty.

The school and its proponents, consistent with a widely held belief of parents and legislators alike, is that early college is a win for all involved. According to this common-sense view, a program that offers early college courses puts students at an advantage: They are able to gain some credits that might help them earn a post-secondary degree and hone their aim towards a future career. Families save money since they do not pay the tuition of a college student, and they can take care of many requirements to advance them towards degrees at many institutions. Representatives of the early college school make a case that their students aren't ready for a full university experience, students they still want and benefit from university credit that is catered to their needs and the high school's pace. The university believes it benefits by giving a student a head start on a transcript at our school, so that they may be more likely to continue studies in our programs after they've graduated from high school. And, there's a general sense by many that we are expediting the educational process so that we help students complete degrees and enter the workforce in a timely manner.

For my part, I feel like I'm living in a kind of augmented reality, one in which the environment is familiar but there are realities placed on top of the landscape that are clearly in existence but don't fit. In spite of all of these common-sense arguments for the early college STEM model on my own campus, I believe that they are inherently inequitable and that they foster new inequities. The first layer of this is in the makeup of the school and how it's promoted: join our campus *if* you have a way of getting here and *if* you have an interest in the early college, STEM focused curriculum. The second layer is more subtle but equally bothersome to me: enroll in a high school where we devalue innovative curriculum that could be taught at the secondary level, replacing it with cookie-cutter university courses that are meant only to check off boxes on a transcript.

Venture

In my mind, schools are for the benefit of individual students' lives and the society in which they are becoming a part. Towards this end, all schools are sacred and beneficial in unique ways, and there is no single model for what a school should be, and most certainly there are many viable curricular. So, what I'm proposing is not a statement of right and wrong. Instead, I think that a large portion of the public's view of schools is in what they see the concrete outcome to be: perhaps a sum of credits or a job placement or the name of a degree. What we generally miss, however, is an overarching goal of any schooling is in the first place. We take it for granted that this discussion or implicit assumption has established the aim of a program or entire school well before the programs have been designed. But we have choices that many probably don't even realize. While we assume "school" has a singular meaning, we should embrace the possibility that the education is not a *de facto* structure, but an invention that we have agency to re-invent.

But my perspective on our current model of the early college STEM school is that it's harmful to students and society at large. It inflates a value on university coursework and diminishes the value of secondary coursework. Simultaneously, the standard model presumes that current students' objectives are for workforce and economy. Since there are finite careers in STEM fields, the leaders or our workforce are presuming that they will take the most successful of these students for their jobs, but inherently others will be left behind. At the same time, it diminishes the value added of a high school teacher, their creativity in curricular planning and their own expertise in education. This is happening, ironically, on the same campus where many of these teachers earned their credentials.

This sets the stage for two facets of my venture. First, I'm trying to figure out simply how to address the fact on my own campus that we are making our own high school that is not in line with a university mission towards equity and access. While I need to figure out for myself some logistics (who to talk to, where stakeholders are, how policy is created), I need help from others to establish a kind of platform with talking points. Is there any model of a university-based, early college high school that *could* equitable opportunities for all students in our surrounding area? Or, is a model in which students need to find their own way to a non-central location simply rigged to help only a few students? Is there a compromise position, one in which early college credits can be given, but not at the expense of a more holistically oriented secondary school experience? Or, is there a model in which "early college" is reframed so that it does not mean university credits are granted, but some other benefit is provided and made available to a wider array of students? And, if I were able to sit down with a university vice president of some flavor, how can I convince them that the very nature of this school and our early college model is inequitable?

Second, I realize that I need to be both pragmatic and proactive. As I turned down the proposal for this teacher to teach a university physics course, we've started to talk about the possibility of him teaching a university course that offers an introduction to teaching; and he could cater this to promote science and math teaching in particular. I could help him design this and possibly (*if* it's possible) find channels to make this available for university credit. While I feel like I'm selling some of my ideals regarding the malice of early college credit, I also recognize that this is what many people want and maybe it's a place where some compromise and advancement could be made. What would that course look like in an ideal world? What models might we have for getting my own preservice teachers involved in that course, or in other courses, to help promote a broader view of STEM and (since there seems to be an emphasis on making people think about future employment) future job possibilities.

Re-establishing My Science Teacher Education for Equity Agenda

Doug Larkin, *Montclair State University, Montclair, NJ*

Vexation

My vexation concerns an issue at the core of my academic career: in summary, it feels that despite all of my scholarly activities I have wandered away from the ur-vexation that lured me away from teaching high school in the first place, and I want to find my way back. In short, I jumped into academia because I saw students shortchanged by a substandard science education, and I thought I that if I was involved in the preparation of science teachers for high-need urban schools, students in those schools would ultimately have greater access to an equitable science education.

After I earned my Ph.D. in 2010, the first five years of my scholarship were focused on science teacher learning for equity, and I had enough data from my overly ambitious dissertation research to keep me going with publications and research tools exported from my work in Wisconsin into my new setting in New Jersey. By the time I submitted my tenure and promotion materials in 2014-15, I had become overwhelmed with the amount of unanalyzed data I had collected, and had my doubts that continuing the same study for another five years was really going to lead me into new territory. At the time, it felt as if the particular line of inquiry I had followed for the past ten years was running out of steam. The book I have coming out this fall is really the culmination of a lot of this work—so in a way I did keep it going—but the truth is that I was ready for a change, and it doesn't feel like I have done much new lately in this area.

By 2015, I had developed a number of other research interests, and I let these smaller, more well-defined projects take priority in my scholarly agenda for the next few years. All of them were tangentially related to my main research interests (e.g. "physics first" as an equity curriculum, the preparation of teachers for juvenile justice settings, school finance simulations for preservice teachers' understanding of equity, and critical race theory analyses of preservice teachers as agents of change.). One big project I have recently undertaken is an NSF-funded 5-year study that examines the factors related to the retention of science teachers in high-needs schools. Each of these efforts has scratched an academic itch and served a genuine purpose in at least attempting to make a contribution to the field, yet looking back on them it is easy to see that I've strayed from the questions that brought me to graduate study in the first place. (And then I was department chair for a year and it was all I could do to keep my research from stalling out altogether.)

What interests me now is the larger question about what our students take with them from methods into their post-graduation teaching, and this is a question and agenda I would like to develop more. In visiting graduates or listening to their stories, I have often been surprised at the ways in which practices that we have rehearsed in methods (such as elicitation strategies) are been taken up and repurposed, sometimes in ways that are not always consistent with the intent of that practice. Others have reported similar findings (Ball & Forzani, 2011; McDonald, Kazemi, & Kavanagh, 2013; Windschitl & Calabrese Barton, 2016; Zeichner, 2012), but still this issue vexes me. Another thing I have noticed—which feels related somehow—is that some of the actual strategies I have used to teach the methods class seem to find their way into my graduates' teaching, even if they are less appropriate for secondary students than they are for college students. I also think long and hard about the messages sent about justice-centered and culturally relevant pedagogy in the methods course, and how these get translated into actual practice. As a field, we already know that this is hard, but I am starting to question if enacting this kind of teaching is even much more difficult than we think because of the feelings of inadequacy it can generate for students. All of this is swirling around as a possible new agenda for research.

Part of the reason that I have found it much more difficult than expected to return to my research agenda is structural. Within my university, methods courses have been the purview of the subject area departments and not the College of Education and Human Services. In practice what this means is that aside from a few grant-funded exceptions, I have not had the opportunity to teach a methods of teaching science (the last time was fall of 2016, and we had to be sneaky and call it something else), even though my initial research agenda on science teacher learning would sit squarely within that course. The reason this is important is because many of the factors that impact teacher learning that I have studied over the years are practices that can be acquired during a methods class, and not having access to these students has been a very real barrier to actually studying them.

It appears that the winds of teacher education reform are blowing at my university once again, and a number of the agreements about who has responsibility for teacher education across campus are in flux. Leadership of—or perhaps more properly, stewardship over— the secondary science education program is going to be critical in the coming months. It is now within the realm of possibility that responsibility for the methods courses will be shifting to my department. This leads me to my venture…

Venture

The venture I propose has two components. The first is to ensure that a robust secondary science program survives being jettisoned from the college of science and mathematics, and thrives in its new (prospective) home in my college. The second is to use this opportunity to reinvigorate my science teacher learning research agenda.

If our college of education is able to capture the methods course from the college of science, I will likely have responsibility for teaching the single Methods of Teaching Science course that all of our science education students take. I am requesting less feedback on this part because frankly it is a political process within the institution that I will simply have to navigate through the relationships that I have built and sustained over the past decade. Of course, any thoughts about this are certainly welcome.

The second component of rebuilding my research agenda is really what I would like this group to help me think about. While I have not been shut out from doing science education research at my university by any means, the consequence of this shift is that I will get to live in this world instead of just visit it. The question before me now is how to construct a new research agenda from the scraps of the previous one that I have left to be weather-beaten over the past few years

What might this new agenda look like? What can one do with access to students in a methods course that could not be done previously? I do not simply wish to search for the evidence of impact of a single course on teacher practice. After all, that type of research has not proved very useful (Cochran-Smith et al., 2015).

At the moment, I am thinking about inquiring more closely into the linkages between the experiences that students have learning in a methods course and their subsequent practice as teachers. Specifically, I would like to examine the process of teacher learning in methods coursework (e.g. Larkin, Monteiro, & Poole, 2015; Marion, Hewson, Tabachnick, & Blomker, 1999; Stroupe & Gotwals, 2017) and then follow this learning after teachers have graduated and have their own classrooms. My initial reaction to the idea of studying such a topic is that it is likely to get swamped by context—in terms of both the entirety of the teacher education program as well as the setting in which graduates find themselves as novice teachers. My sense of the current literature on this topic is that it is focused primarily on science learning, but I am also interested in how science teachers draw upon resources to solve specific, context-dependent problems, as well as issues relating to the intersection of justice-based curriculum and pedagogy, planning, and the problem of enactment (Hammerness et al., 2005; Kennedy, 1991).

So given the problem space, the deliberations that would be most useful for me are those see access to the Secondary Science program—and methods in particular—with fresh eyes. I am hoping to generate possibilities for research opportunities, both in terms of the actual questions that would further the field as well as the methods and approaches that can be used to engage in these inquiries.

Centering Youth in Youth-Centered STEM: Whose STEM learning stories are being told?

April Luehmann, *University of Rochester, Rochester NY*

Vexations. Whose stories are being told? How can informal educators and researchers support youth in narrating ***their*** STEM stories in ways that contribute to conversations of equity?

Informal educators are often committed to empowering youth through programs that engage them in authentic work that makes a difference to them and the people they care about (e.g. Boullion & Gomez, 2001). Understanding teen depression and fighting to change unproductive narratives that add to the problem, creating a "hopeful" future for the neglected lake behind the school, and engineering improvements for perceived ecological needs are just three projects that my colleagues and I have supported youth in taking up and taking on. Seven years later, the young women who had engaged in this work have stories to tell of the consequentiality of their learning and engagement in these projects. The vexation I bring to the table is this: ***How can informal STEM educators and researchers support youth as participants and as participant researchers in communicating their STEM experiences and narrating these stories in youth-centric ways that maintain the integrity of their experiences from their points of view while also shaping the stories sufficiently to contribute to broader conversations of equity*?**

The equity dimension: Young women of color often don't see science and engineering as important or relevant to their lives (Eccles, 2005). Attending schools that have been labeled as struggling can add to the problem as teachers understandably respond with increased focus on using class time to prepare for standardized testing and coverage is prioritized over student interest (Settlage & Meadows, 2002). Lacking an appreciation for and a lack of identity in science can lead to a dramatic shrinking of opportunities for young women as they make choices regarding both how they engage in their present lives as well as ways in which they imagine possible futures. Designers and educators of informal learning spaces take up this challenge by giving youth opportunities and support to conduct science and engineering projects that are more authentic (ill-structured, human, situated) and relevant (driven by their interests and voices) and more relevant (taking up issues that matter to youth now versus issues that may or may not matter in their future). There are many points in the STEM project process (design, investigation, communication and retrospective analyses) in which facilitators/researchers are seeking to simultaneously hear, honor and amplify the voices of young women of color while expanding their opportunities and positioning them and their contributions for impact and recognition in larger conversations. The authoring challenges these aims involve are complex for adults, so they would also be challenging for the novice narrators we seek to serve.

The STEM education dimension: Science and engineering are human-shaped enterprises that are often controlled by discourses of dominant groups. Western science has a deep-seated history of being dominated by white patriarchal norms at the exclusion of all other groups. Women and people of color have been excluded in STEM in practice, purpose and historical narrative (Calabrese Barton, et al., 2013). It is a fundamental responsibility of education to reshape these norms to be inclusive and relevant, especially to those whose voices have been silenced in STEM in our country thus far. Informal STEM learning spaces are rich with potential to invite youth to write counter-narratives about what science is, who does science and how, and why science matters personally, to our community and to our society at large (Adams, Gupta, & Cotumaccio, 2014). ***These counter-narratives are clearly important stories to be told, but counter-narratives are also challenging to author, be heard, and be respected*.**

The leadership dimension: To address unequal access to STEM, minoritized youths' stories in STEM need to be nurtured, authored and shared. Informal educators and researchers can and need to use their privilege and power as adults with access to decision-making and perspective-impacting conversations to support the amplification and legitimization of youth experiences and priorities. Without thoughtful and careful attention to maintaining the integrity and personal perspectives of the participating youth, the shaping and amplification of their stories for outside audiences including parents, community members, and academia can result in the coopting and re-authoring of their stories for purposes other than their own. Well intentioned adults with literacies different from the youth they work with may tap into their command of more powered forms of communication to distil and advance their own aims and objectives at the expense of the youth, perpetuating their silencing – the exact opposite reason they began the work. This unintentional influence from adult perspectives may deprive youth's opportunities to critically engage in and take leadership roles in researching the issues rooted in their communities, therefore stymying the development of youth scholar identities. ***How to share and even yield power for youth and break down the inherently unequal adult-youth relationship within this co-facilitator and co-researcher work remains a challenge for us (Allen-Handy & Thomas-EL, 2018).***

Particularly Vexing Questions include the following:

- **Is it possible to invite youth into the advocacy work that the adults in the project have — without introducing a sense of coercion by the adults they have grown to love and trust?**
- **If one audience of youth stories is academia (e.g. for a course such as "Adolescent Development and Youth Culture), how much do participating young people need to understand the larger conversations and particular language being used in order to maintain authorship?**
- **Compared to articles or books, what might be parallel audiences and authoring projects that could matter more to minoritized young women in general and the women in our project in particular?**

Ventures. Having developed many afterschool programs as both an educator and a scholar, I am in the position of working with my research team to support approximately ten young women who participated in my annual Science STARS science film program in the years between 2011-2016 as participating researchers to conduct a phenomenological study of their learning in and through STARS that they perceive to be consequential in other aspects of their lives in the eight years since (Hall & Jurow, 2015). (They are now three years out of high school and STARS). After presenting our collaborative research at AERA in Toronto this past April, the young women were invited to author a book about their experiences. Throughout the inquiry we have conducted thus far in partnership with these young women, we have invested significant effort to collaboratively develop creative methods to draw out their perspectives using literacies familiar to them. These methods have included writing film critiques of various scenes of their final film projects, using artifacts for stimulated recall, and constructing personal meaning maps (Calabrese Barton et al, 2015), first with individuals and second, with a significant narrator in their lives. Combined with film as the core tool to do and communicate STEM in the first place, our "Ventures" have revealed important insights into ways to support youth in storying their own STEM inquires and experiences. That said, as we embark in future work that involves more conferences and authoring a book, we face significantly more vexations about ensuring the stories are their own, and the STEM work they are doing is for their benefit and their purposes. We struggle with asking the young women we have come to know and love (me especially).

The strategies we are contemplating include the use of PhotoVoice to draw out stories from the young women about where they have seen learning from STARS re-emerge in other aspects of their lives including but extending beyond the science and engineering studies they have conducted. After sharing five pictures and captions each young woman captured at a collaborative meeting, we will invite them into two or more revisions of this work, adding photos/videos and captions. The captioned stories will serve as starting places for interviews of each young woman by a personal mentor from the research team to produce extended captions. We imagine, possibly, each chapter of the book to be one young woman's story of Science STARS and since, unpacking the ways in which each young woman's story of science, advocacy and identity has been shaped (or not) through the relationships and work of the club. Each chapter will be written in collaboration between one young woman and her research group member. In addition to a book, the "chapters" will serve as filmic episodes for a follow-up film the young women have been asking to produce. The focus of both the film and the book needs to be negotiated with the participants but I imagine it might take on making the case for the importance of young people taking action in their own lives and the powerful tool that STEM might serve in that work.

Lessons learned from this Venture and Vexation at Crossroads could benefit all informal educators supporting youth in constructing narratives of their STEM investigations for stakeholders in and beyond their lives. Implications will be drawn for the development of curricular supports for people working with minoritized young people, in both practice and research.

When Educators Don't See Us: Developing STEM Educational Leaders for Black and Brown Children

Stefanie L. Marshall, *University of Minnesota-Twin Cities*

Vexation

In my time as a researcher, I have worked with many people, but it was Principal Connell (pseudonym) that deeply concerned me. When walking down the hall with Principal Connell on my second day of field observations, I saw a White teacher and her class stopped in the hallway. The teacher called one student, a Black little boy, out of the line. As we approached, the teacher bent over with her finger in the child's face and waved her finger as she yelled at him. Principal Connell then went over to the student, bent down, and asked, "Did you hear Ms. [teacher's name]?" Her tone was firm. I was deeply disturbed but understood I was a visitor in that space.

The next day, I was scheduled to conduct my first interview with Principal Connell. I started with my science related protocol, but was still disturbed by what I had witnessed the day before. During the interview, I decided to engage Connell on what I had witnessed — with a twist. I asked Principal Connell about her take on the tone I heard from a White teacher speaking to a Black child and her approach to responding to underlying beliefs some teachers may have about teaching students of color (Delpit, 2006; Emdin, 2016). The following excerpt is from the interview with Principal Connell.

> ***And you're not telling me anything different [from the] school quality reviewers…[they] picked up on the same thing you did, and were like, "If I were in that teacher's classroom I would be a pile of mush right now." It's not because she said anything — she didn't say you suck, but her tone. How she interacted with them, how she spoke at them, not to them, or with them…you're right it's in the tone and body language and how do you change that except try over and over again to bring it up and revisit it?*** Interview 1

I approached this conversation based on coaching training — assume the affirmative. I assumed Principal Connell knew what happened was racist in nature and that she wants to do something—but it was clear that she did not know and was not planning to do anything, given she affirmed the teacher's behavior.

Principal Connell is not uncommon. However, she is the instructional leader. But I question how can principals like Principal Connell make equitable decisions for science, when they have limited experience in examining their own positionalities? I found it challenging as a researcher to stay focused on science in the midst of an unstable environment for students. Beyond Principal Connell's limited capacity to address racist behaviors towards children in her school, I found that she did not respect me as an expert, which makes it challenging to be the change-agent in the field of science education that I aspire to be. On one occasion, she asked me, "So what do you plan on doing with your doctorate?" I stated I plan to become a professor. Her response was, "Wow, so you plan on doing big things." By shadowing her, collecting data, I was essentially re-establishing her privilege.

We ended the interview that day by talking about books that Principal Connell could potentially read and hopefully one day read with her staff. Principal Connell discussed my recommendations with her superintendent who later purchased the texts for Principal Connell — he understood the urgency.

Figure 1 is a series of texts from Principal Connell. She referred to me as "adorable." I'm Black. I'm a woman. I'm an expert, rather than adorable. What I know is that supporting principals in being science leaders must first provide professional learning opportunities enabling school leaders to engage critically about their own positionalities and beliefs. Striving for equity in science (based on my own work) must first start with addressing the hearts and minds of school leaders involved. Otherwise, they will not truly see their own students of color, and they will not see me, or those like me, attempting to engage them in this critical work.

Figure 1

Venture

> ***Leaders who are not critically self-aware or knowledgeable about racism and other histories of oppression, and who do not embrace anti-oppression and social justice, will reproduce racism and other forms of systemic oppression in their schools.***
>
> ~ Muhammad Khalifa in *Culturally Responsive School Leadership (pg. 24)*

I currently teach future teachers about culture and race, that is at least what the university says I do. I tell my students, regularly, that my goal is to make them better for kids. I do this by promoting deep introspection — me-search. Students then examine the experiences of students so they are then prepared to consider how they can show up for students. We end the class considering their role as part of a community. In my other role, I teach future science teachers with the goal that we desettle (Bang, Warren, Roseberry, Medin, 2012) their understandings of science in order to engage all students as doers of science. My science education students have already taken the "culture and race" class, and they come to me and I talk about oppression, communities, and race explicitly. Now I am considering, ***how is this not done with our school leadership, at least not regularly*** — considering their own racial and cultural identities, then looking at their roles when considering curriculum and being a school leader.

I have raised the notion of a Community Science Leader (CSL) — one who does not see their instructional leadership work in science as limited to the walls of the school, but rather knows that their actions enable students to go back into the local community and work, serve, and contribute to society with science capacities. A CSL seeks culturally, racially, and positionally empowered colleagues to engage their own social justice-oriented science goals. I developed this notion without considering- principals are not yet prepared to be a CSL without working on themselves first. Therefore, I am arguing that the premises of Culturally Responsive School Leadership (CRSL) (Khalifa, 2018) can potentially advance the future of science education for our most vulnerable populations. Science education is specifically taken up in the premise that "CRSL is characterized by a core set of unique leadership behaviors, namely: (a) being critically self-reflective; (b) developing and sustaining culturally responsive teachers and curricula; (c) promoting inclusive, anti-oppressive school contexts; and (d) engaging students' Indigenous (or local neighborhood) community contexts" (Khalifa, 2018). Principals must first be culturally responsive to effectively become a CSL.

Evidence of this needed work was found by work with instructional coaches (Marshall & Khalifa, 2018). We found that culturally responsive instructional coaches were limited in their abilities to work with teachers in being culturally responsive if the teachers did not also have a culturally responsive orientation. I have an opportunity to develop a workshop for school leaders that would enable me to do what I am proposing with an equity lens. Developing a workshop would enable me to:

1. Engage school leaders on culturally responsive science or/ and STEM (given these areas are often conflated) leadership
2. Orient school leaders in defining STEM in their district (if appropriate)
3. Bridge the gap between leadership and science

Being in Principal Connell's building robbed me of a bit of my soul during each visit. I was concerned for children—not just science. I was able to push a bit. However, I know until principals like Principal Connell consider their own racist, biased, and oppressive interactions, researchers like me will not be heard. Our work will not be valued. Said another way, if a White man walks into her office with the same goals as me, I am confident she would not text him that he is adorable.

Interrogating Whiteness in Science Education

Jonathan D. McCausland, *The Pennsylvania State University*

Vexation

As a white man, I could ignore that most science teachers are white, most students in advanced science coursework are white, and most scientists are white in the United States. I can ignore it because I am white, and being white in the United States means I carry white privilege. The overwhelming representation of white people in science education did not happen overnight. In fact, it can be traced back to the genocide of Indigenous people by white settlers and the African slave trade. Considering race was initially created as a political category to maintain wealthy white men's power, this history is something I cannot ignore. As Roberts (2011) states, "scientists were instrumental in inventing the concept of biological races, in specifying their demarcations, and in justifying the social inequalities between them" (p. 27). Therefore, I ask, how can we, as a community, grapple with equity in science education without acknowledging the discipline we teach supported and was supported by white supremacy and interrogating how we might still be supporting it through our science pedagogy?

As I wrote the question above, I wondered if it would be dismissed as overreach or taken as a cheap shot? I expect these reactions and they point to the core of my vexation: whiteness. According to Jupp, Berry, and Lensmire (2016), whiteness is the, "hegemonic racial structurings of social and material realities operating in the present moment that perpetuate racialized inequalities and injustices" (p. 4). In other words, whiteness is an ideology that polices how people speak, act, and view themselves and others (Thandeka, 1999). This description is important because it recognizes that white people can choose not to participate in whiteness, just as some people of Color can choose, potentially unknowingly, to participate in constructing whiteness, albeit for different reasons (Leonardo, 2002). This is possible because, according to Haviland (2008), whiteness is "powerful yet evasive" (p. 44); it "employs numerous techniques to maintain its power" (p. 47); and is "not monolithic" (p. 42). This is how, racism can remain foundational to science (Sheth, 2019).

With this said, I did not arrive at my curiosity by chance. As a white teacher, I attempted to teach the students of Color in my classroom using culturally responsive pedagogies (Ladson-Billings, 1995). Unfortunately, my commitments to anti-racism were not enough to overcome my own learned practices of whiteness and the whiteness inherent in science. In one lesson about genetically inherited diseases, my students asked, "Mister, why did you choose to write the people with the disease in *black* marker?" Mortified, I realized I had used two colors, black and pink, to represent diseased and healthy individuals respectively. I panickily promised to be more cognizant next time. This moment demonstrates some ways whiteness controls actions in science classrooms. Through my drawings, I embodied how white bodies are privileged over Black bodies. Beyond this, my reaction to apologize and move on centered my own distress and robbed my students of a potential opportunity explore the relationship between race and science/genetics. Had these critical and brave students not given the gift of *teaching me* about what I did, I would never have realized it. As a white teacher educator, I want to be as critical and brave as my students by helping the interns I work with navigate whiteness in their practice. I believe it should no longer be up to people of Color to educate us about our whiteness.

In the classes I teach, I push interns to leverage their students' experiences and promote student agency. However, this does not always radically alter the historic asymmetrical power imbalance present between science and many communities of Color because of how whiteness can enter science teaching. This is exemplified by the co-construction of a word for potential energy in a class I observed. The initial word created (a portmanteau of height and weight) was pronounced, "hate." Quickly, the teacher adeptly moved them away from that word. Soon after, the students decided on the reverse combination, wheight, which students pronounced, "white." This time, the teacher made a less convincing attempt to move the kids away from the word. As a result, students pounded their tables chanting, "white, white, white…" I looked around the room and spotted the few students of Color sitting. Silently. After the event, when I spoke to the interns and others, many of whom are white, most dismissed my interrogation. I have no way of knowing what that moment meant to the students of Color, but it still unnerves me. Again, this moment presents a challenge because until we, as a primarily white community, fully understand our discipline as racialized and help all educators, including teachers and administrators, grapple with the whiteness in their lives and practice, many of the reforms currently in place might actually be solutions to symptoms of a larger problem, a systematic presence of whiteness in science education (Le & Matias, 2018).

Jonathan D. McCausland, *The Pennsylvania State University*

Venture

In the methods courses I help teach, I am not interested in using "white privilege" (McIntosh, 1988) when speaking about equity. Under white privilege, anti-racism work is rendered to a list of items that should be rights rather than privileges, framing privilege as interpersonal rather than systemic, and thinking of white people as a static group (Lensmire et al., 2013). In many ways, anti-racism starts and stops, for white people, with confessing our privilege. A white privilege framework allows me to view white teachers as deficit too (Lensmire et al., 2013; Settlage, 2011); causing me to worry about how my interns will teach if I model teaching that views them through a deficit lens. My solution to these tensions was having interns complete a "self-ethnography," a new pillar in Penn State's methods coursework.

The self-ethnography requires the interns to examine their identity through the analysis of salient narratives. Throughout their two methods courses they revise the paper 6 times with certain drafts focusing exclusively on race, gender, and ability. As they enter classrooms, the self-ethnography transitions from how they see themselves, to how they see their students. Although we do provide some readings to guide their thinking, the writing and discussions the interns engage in are entirely open because I designed the assignment to help the interns "play" with ideas around identity and equity. Rather than police their thinking, we attempt to provide a space for them to describe and question their lived experiences as well as how students of Color are oppressed by systems and science teachers in, "normalized, seemingly non-racial, day-to-day ways" (Sammel, 2009, p. 650). While there are shifts in how many interns think about equity in classrooms where they observe and teach, including my own, I have concerns about the approach we take.

My most prominent concern is that the assignment and discussions I designed are re-centering whiteness in potentially dangerous ways by allowing the white interns to "play" with whiteness. Second, while the white interns speak to their racialized identity, they struggle to speak about it in relation to science learning or teaching; a key part of this venture. Additionally, I recognize our pedagogy creates potential to reproduce structural inequalities already experienced by interns of Color. While I believe interns of Color also need to interrogate whiteness, I recognize that white instructors working with interns of Color around these issues is tricky. I worry that in a radically open environment where white interns are "playing" with race, interns of Color can be marginalized in class. Therefore, I am trying to find a balance between my belief that white people need to grapple with race freely and knowing that people of Color deal with race daily, in potentially traumatizing ways, without the choice to ignore it like myself and the white interns. The balance of avoiding both confessionals and trauma is a needle I know I need help threading.

This venture has also taken on a leadership dimension. First, knowing the "self-ethnography" assignment is now a central element to the Penn State secondary science methods sequence, any changes I make to it will remain beyond my time in the program. Beyond this, while I want the interns to grapple with whiteness and their identity throughout the assignment and course, I also want them to begin to enact anti-racist teaching practices. Given that the foundation to our methods course is Ambitious and *Equitable* Science Teaching (Windschitl, Thompson, & Braaten, 2018), I hope they will begin to recognize the ways the pedagogical model we provide them with is potentially inequitable and work to change it. Additionally, given that one semester of Penn State's methods sequence is embedded in the local middle school, as a part of a research and practice partnership, this work has potential to go beyond the walls of Penn State if the interns bring their focus on social justice to the school. This means we as an instructional team must support the interns' capacities as leaders. Finally, as a scholar that believes in the philosophy behind Ambitious and *Equitable* Science Teaching, this work could aid in understanding the potential short comings of a valuable pedagogical model in terms of how it addresses ideologies of whiteness like "science as white property" (Mensah & Jackson, 2018) and adapt it accordingly. With all this said, I am hoping the community will engage in a critical and productive conversation that will help me think through the following questions about this work:

1. How can I allow white interns to discuss whiteness openly and freely, without reverting to policing their ideas, while honoring the experiences of and recognizing the potential for marginalization of interns of Color who share the space?
2. What are your thoughts on the re-centering of whiteness, with a critical eye, in order to address underlying issues of inequity that still exist in science education broadly?
3. How do others handle discussing whiteness, race, and anti-racist science teaching with your interns, and do you have any suggestions on how to put these analyses into a concrete practice or practices that go beyond interrogating the existence of inequities in science structurally or planning practices?

Considering Special Education Students as a Critical Equity Community for Science Learning

Scott McDonald, *The Pennsylvania State University*

Vexation

For the past ten years I have been working with an amazing group of middle school science teachers in a research and practice partnership focused on what we now call Ambitious and *Equitable* Science Teaching (Thompson, Windschitl, & Braaten, 2013). My vexation is really grounded in the third word in that phrase. First, because it does not always appear when scholars name the practices and is more commonly just Ambitious Science Teaching (AST). Second, how equity is integrated into AST practices is not clearly and explicitly articulated; though that work is forthcoming (e.g. Thompson, et al., in press). There have been scholars in the AST community who have considered equity (e.g. Kang & Zinger, 2019); however, the focus tends to be on cultural and linguistic notions of equity. One community of students not typically part of the equity conversation, either in AST, or in science education more broadly, is special education students. My program at Penn State, as a historical artifact not worth detailing here, has an explicit focus on special education students in science. I have found in my work with middle school teachers and students that there are specific challenges and complexities to working with special education students that stem not only from their needs, but also from the intellectual and practice foundations of the field of special education. My vexation centers on how to reconceptualize the practices of AST in a way that engages special education students in authentic (McDonald & Kelly, 2012) and epistemically agentic (Stroupe, 2015) ways.

Parallel with my developing research practice partnership, at the 2011 at Crossroads in San Antonio, I began a friendship with Dr. Jonté (JT) Taylor, at that time a post-doc in special education and science education at the University of Iowa. We talked at dinner one night while we ate wonderful Mexican food and listened to a mariachi band. As JT tells it (and I tend to believe him), at some point during our conversation I asked him: "Do you believe in direct instruction?" At that time, I would say that I did not have a nuanced understanding of special education, but my question to JT was and is at the heart of my vexation. I wondered why it was necessary to structure teaching of special education students the way we do, and furthermore, if that structure was an artifact of the way schools are, or if there were deeper reasons for it. The reason for my question then, and my continuing vexation, is that I truly believe (and have theoretical and empirical basis for believing) that AST has a profound impact on the way teachers teach and the way students learn, AND I simultaneously recognize that AST puts significant demands on students in terms of both oral and written discourse. To engage in AST is to authentically engage in scientific explanation of the world, and just as scientists must talk and write to do science, students need to as well. As a result, AST can and does marginalize students who have communication or cognitive issues that make it more difficult for them to engage in the mangle of practice (Pickering, 1995) that is the progressive discourse (Bereiter, 1994) of knowledge production in a classroom. So, while my question was to JT, it was more fundamentally to myself – how can someone who believes that direct instruction is antithetical to good instruction work with students for whom this form of instruction is widely regarded as effective.

Fortunately for me, JT has since become a faculty member here at PSU, and has been willing to think with me about these issues of science pedagogy and special education. Dr. Taylor is already aware of the tensions, as he is one of the few special education faculty members in the country interested in science (e.g. Taylor, Tseng, Murillo, Therrien, & Hand, 2018). The vexation seems particularly thorny as it requires navigating all the usual complexity of working with practitioners in schools, while adding the complexity of border crossing two divergent fields of practice and scholarship, and building relationships with the practitioners and leadership across those communities. It is likely to be both a wicked (Borko, Whitcomb, & Liston, 2008) and deeply interesting problem, but those are the best kind.

Venture

The venture(s) I am interested in are related to my science method course. This fall, for the third year, my course, which has traditionally taken place in an on-campus classroom will be embedded in a local middle school with my research practice partners. This means my interns will simultaneously be "in class" with me, while also being in a classroom with middle school students and a mentor teacher every other day from 8:30-11:30. The school is on a block schedule, so this every other day pattern means my interns are seeing the same group of students for the entirety of those students' science experience. For the first half of the time each day, the interns and mentors in 8th grade classrooms are with students, and the 7th grade interns and mentors have a prep period. The second half of the time the pattern switches and 7th grade is teaching and 8th grade has prep period. This allows for both a field experience component, where interns can work with students, and either a before or after discussion about teaching practice. In 7th and 8th grade classes there are different numbers and types of special education students, from gifted to IEP supported students with in-class aids. This is the context for the work I want to do around special education and AST.

The class is organized around a number of tasks designed to scaffold interns' development of AST practices including: a self-ethnography, a theoretical framework, structured and progressive rehearsals with students that are video recorded and analyzed, lesson and unit planning, and specific instructional planning for a targeted special education student by each intern. This is the skeleton, but I also want to make sure all of these activities are grounded in socio-cultural perspectives on learning and by extension principles that serve as the foundation of AST. I don't wish to position special education students as having a deficit, and I also do not want to make assumptions about their capacity based on my own ignorance of their needs. I want to be sure that any supports or design elements to support interns' learning about special education students included in my methods course reinforces the value and capacities of the students in their classrooms. I also want to think about this as an opportunity to improve and deepen the practices of AST, not as a context to develop remediation or modifications that allow for lesser quality participation.

This venture also touches on issues around leadership, as my teacher partners and I are writing the middle school science curriculum for their school district, and any structural supports designed for special education will likely be written into that curriculum. Additionally, the middle school teachers and I are providing professional development for all the other middle grade teachers in the district as a result of this new curriculum. I would also be adding the participation of special education teachers and faculty to the conversation about science curriculum, which broadens both the scope and the leadership responsibilities of the teachers, myself, and Dr. Taylor. All this means I need to support and contribute to the development of the leadership capacity of the mentor teachers I am working with to write curriculum, and develop a collaborative relationship with teachers in special education. This venture is well aligned with this year's theme for Crossroads focused on equity and leadership, and I am hoping the community can help me think through some key questions about the work:

1. What are your thoughts about how to reconcile socio-cultural perspectives on learning and the more typical behaviorist perspectives of special education in the context of science learning?
2. What experience have community members had with providing leadership around bringing together stakeholders in productive conversation when there are significant differences in underlying models of learning?
3. Do others have experience supporting special education students engaging in discourse-rich pedagogies, or perhaps working with other groups of students who might be informative to my venture?

Terrell R. Morton, University of Missouri

Vexation

I have an issue with how equity, diversity, and inclusion in science education practices and policies have remained stagnant in addressing oppressive and racist institutionalized policies and procedures that pertain to, support, engage, or involve Black students and people. My vexation is situated within a critical examination of ***interest convergence***, a principle of Critical Race Theory that states that groups in power (White people) will only concede aspects of their power or invest in others if they directly benefit from them (Bell, 1980). In that vein, I find efforts that promote and focus on equity for Black individuals in science education are not prioritized by science education leaders (e.g., administrators, funding agencies, policy makers, mainstream scholars and journals). These individuals' approach towards equity is a stance based on principles of diversity and inclusion. Rather, true equity efforts in science education for Black people are grassroots endeavors pushed by a finite, niche community who have to use interest convergence—that is take a diversity and inclusion approach to appease and accommodate science education leaders—to advance an equity agenda. While I value and am in support of diversity and inclusion efforts, I find that these approaches are often co-opted by White individuals to protect and maintain whiteness (for definitions of whiteness see Harris, 1993) through policies and structures enacted upon others (Aguirre, 2010) that constrain, limit, or retract any progress made among or for racialized and minoritized individuals. Protecting and maintaining whiteness is particularly evident in the field of science education (e.g., Le & Matias, 2019; Mensah & Jackson, 2019; Parsons & Thompson Dorsey, 2015; Walls, 2016).

Science education leaders promote diversity and inclusion efforts across the P-20 and workforce continuum (e.g., NASEM, 2018; NSTC, 2018). These efforts are facilitated by their desire to increase human capital in science fields as a way to advance the preeminence of the U.S. and its global economic standing (Barber, 2015; Basile & Lopez, 2015). Through interest convergence, I find that while leaders will emphasize increasing access, participation, and retention, ***there is not a specific focus or desire to change policies and procedures that inherently racialize and minoritize Black people*** and their experiences when engaging in or creating science given the relinquishing of power and privilege that comes with this perspective. For example, despite funding and support for engaging students in undergraduate research experiences there have been limited changes on Black student retention and matriculation in science (NASEM, 2017; NSB, 2018). Relatedly, there is little evidence of protracted efforts to research, change, or challenge existing structures of undergraduate research experiences to unpack or dismantle how racialization and minoritization occurs within these spaces that influence Black students' continued participation in science (Morton, under review). There is a fundamental issue with the culture, climate, and perceptions of science as a discipline that generates stereotypical and alienating mentalities towards Black students while favoring and privileging White middle-class men as the standard or norm (Parsons, 1997; Wong, 2015). Existing endeavors from science education leaders, given their focus on diversity and inclusion, do not address or account for this culture and climate, thereby facilitating racialized inequity for Black students and people in science.

As a Black science education scholar-activist committed to the liberation and joy of my community, I am troubled with the existing perspectives surrounding equity in science education. While I understand many groups are marginalized within science education, I focus on the specificity of Black people, attending to their contextual experiences within science as a way to develop a robust response to their group-specific histories and types of oppression experienced (Ridgeway & McGee, 2018). I am troubled by the destructive impacts of interest convergence that pervades the drive for equity in science. I am repeatedly frustrated by funding and support provided to mainstream individuals and institutions gaining notoriety for "doing equity work" but not changing the policies and structures that perpetuate inequity on any level (university, community, or society). I am frustrated by the niche community having to adopt or accommodate mainstream mantras to pursue equity. I believe that this faux-equity cycle promotes interest in equity work that ultimately stifles the progress of racialized and minoritized communities. I also believe that this faux-equity cycle makes it even more difficult for those living and engaging equity in all aspects of their life and work beyond research and funding to truly dismantle oppressive structures or maintain wholeness and self-care. If the science education community fails to address this concern, I feel that the community will continue to remain stagnant with promoting equity, and will soon begin to regress in any progress made given the current views of the U.S. political climate involving science and education, as well as the increase of overt and covert racist actions (see Thompson Dorsey & Venzant Chambers, 2014). I also feel the equity-driven scholars, over time, will continually "burnout" and stop fighting.

Venture

Given my troubles with the current positioning of equity within science education and my critical examination of interest convergence among science education leaders and others to disperse or obtain support to do equity work, I take an oppositional approach towards existing notions of science education with my endeavors. I engage my research-praxis with an unapologetic frame that envisions the liberation and joy of racialized and minoritized communities in and through science education. My work towards liberation includes re-imaging the ways by which we teach, learn, and research science, building it upon a foundation that accounts for individuals' racialized experiences and situates Black joy at the crux of their engagement. In doing so, my work simultaneously challenges the status quo of "what is science," "who is science," and, "how do we engage, learn, and know science," promulgating and promoting Black individuals' ways and being as authentic, valid, and valuable within and among this epistemological space.

It is my goal to progress toward liberation in and through science, accounting for and redressing its convoluted and oppressive past and present (for challenges see Brown & Mutegi, 2010; Green, 2014; Mutegi, 2013). I seek advocates and co-conspirators (Love, 2019) who do equity work for the sake of justice but not motivated by interest convergence. I specifically feel that if science education leaders take a liberatory stance towards equity, there would be no drive for interest convergence. In the current structure, I do recognize that as Frederick Douglass stated back in 1857, "power concedes nothing without demand" (Blackpast, 2007). With that in mind, I ask, what would it mean if those in power facilitated and supported equity because it is just? What would it mean if those in power facilitated and supported equity for aspects of liberation? What does it mean to engage both of these practices within science? And, in recognizing both the power and limitations of interest convergence, what does it mean to transcend this notion to foster true equity in science?

In efforts to transform science education and life through science education, being guided by philosophies that prompt liberation and joy, I find myself positioned at a crossroad when it comes to my scholarly and activist identity. My work exists within two areas, identity as it informs Black students' postsecondary STEM engagement and transforming undergraduate STEM education learning environments. Despite my current and on-going progress and success, I still struggle with enacting the transformative change I strive to obtain. To orient myself towards the liberation and joy that I desire, I work to create a space for myself that operates outside of the bounds of faux-equity driven STEM education leadership, policy, and practice. So far, this includes: a) using my scholarship to openly critique existing structures, pointing out how oppression is continually reified in postsecondary STEM education while also promulgating the power, beauty, and ingenious nature of Blackness embodied in and through STEM; b) using conferences and presentations as opportunities to cultivate my undergraduate students so that in returning to our institution they can use their knowledge and skills to advocate for and promote change; c) applying for funding that promotes changing hegemonic institutional policies and practices that marginalize Black individuals (e.g., tenure and promotion guideline, admissions, student support services) by engaging dialogic learning communities rooted in critical race theory, creativity, and organizational change; d) challenging my colleagues to attend to how they promote equity (or inequity) within their ideologies as well as any departmental policies and practices presented; and, e) operating outside my college (and to some extent university) to build a network of scholar-practitioner-activist dedicated to and engaged in this work.

My approach, at the moment, seems very incremental and individualistic (e.g., working to cultivate the hearts and minds of individuals). And the work that is the most fulfilling and meaningful is not valued, appreciated, or received by STEM leadership because it challenges the status quo and goes against the grain. Examples include mainstream journals telling me to exclude aspects of my argument because it may not be "appropriate" for their audience, conferences grading my work as superior but not accepting it, and institutional leadership promoting my success as "evidence" for diversity and inclusion but not using the outcomes to prompt change in their practices or telling me to be mindful of what I do because of tenure. Given my goals, identity, and challenge, I ask, how might I expand my work to foster liberation and joy in and through STEM in ways that are not incremental and individualistic? How do I create the Afro-Futuristic STEM learning space using the tools and resources of the academy? Or, can the master's tools truly not be able to dismantle the master's house? How do I resist the temptation of "focusing on tenure" before engaging real equity work or continually co-opting "diversity and inclusion" efforts? How do I do this work without burning out, knowing this plight? How can I be free? How can I ensure the freedom of others?

Increasing Inclusiveness of STEM Departments for First-Generation College Students: Investigating Mentoring Relationships

Stacy Olitsky, *Saint Joseph's University*

Vexation

In order to increase access and inclusivity within STEM departments at Saint Joseph's University (SJU), the university will be implementing a new program, *Support and Transform to Excel in STEM*, beginning in Fall 2020. This program will provide scholarships and various supports, such as research opportunities and mentoring, for STEM majors who are first-generation college students and/or from economically disadvantaged backgrounds. One goal is to improve recruitment, retention and graduation rates for students from minoritized backgrounds in five STEM disciplines (Biology, Chemistry, Computer Science, Mathematics, and Physics). I will be involved as the education researcher, investigating the experiences of first-generation college students in STEM departments at SJU, and exploring the impact of the new mentoring program on students, participating departments, and the institution as a whole.

Due to the composition of the departments, faculty and peer mentoring often will be taking place across differences in socioeconomic status, race, ethnicity, and/or gender, which could impact students' sense of belonging. In order for university STEM departments to become more equitable, it is important to understand ways in which crucial social interactions between mentors and students can provide adequate support. In addition, it is important to explore any obstacles to effective mentoring across difference in order to generate ideas for improvement.

This study has not begun yet, however, I am currently conducting literature reviews and designing the methodology. It is my intention to evaluate the ongoing research project using Guba and Lincoln's (1989) criteria for validity and authenticity in qualitative research. These criteria entail fairness, an emphasis on participants increasing understandings of others' perspectives, an iterative relationship between theory, data collection, and data analysis, and working with participants toward positive change in local settings. It is therefore the intention of the research to not only explore general understandings regarding mentoring across difference in the STEM fields, but also to generate insights that can help inform the new program and the inclusiveness of STEM departments at SJU.

I am experiencing some vexation regarding planning for an authentic research approach that will have a positive impact in local settings. In my past experiences as a researcher, when I drew on Guba and Lincoln's ideas, I was working either in a classroom or a program in which I was a participant observer. My role was to conduct research, generate findings and work with participants towards positive change. However, in this new study, I am differently positioned as colleague to the STEM faculty who are in the study. In addition, I am already involved through service work in university efforts related to diversity and inclusion. Last year, bias incidents were reported on campus (e.g. Faguy, 2019), which have increased attention to the need for substantive change regarding the inclusiveness of the university. My own roles have included serving on a Curriculum for Climate Steering Committee and working on a "needs assessment" for faculty members regarding professional development for increasing inclusivity of their courses.

Given my role as more than a participant observer, I am experiencing some "vexation" regarding how to address potential obstacles to effective mentoring that may be explored in the research. While it is likely that the study may uncover mostly positive results of the new mentoring program, it is also possible that issues will arise regarding mentoring across difference. If inequalities around social interaction within mentoring become visible through this study, what are the ways to proceed that would be most productive, authentic, respectful and equitable? Given that the faculty members have an interest in mentoring the students, disconnects are likely to be inadvertent. Calling attention to issues regarding social interactions within classrooms or mentoring relationships may touch on confidentiality issues. Also, if a student is experiencing microaggressions in a classroom from a faculty member not involved in the study, how should this be addressed in order to effect change, and do so in ways that respect everyone's (students, faculty members) confidentiality? I have found that qualitative research that includes working with participants towards positive change more straightforward when I am in the role of participant observer. However, this is the first time that I have been in the role of studying programs within my own university, and I find it challenging to consider navigating my role as researcher, colleague, and faculty member with an active role in working towards university-wide changes regarding diversity and inclusion. It is a much more sensitive situation for me to be researching students' varied experiences within their college STEM courses, undergraduate research, and mentoring at SJU.

Venture

The venture itself I believe is a valuable step towards increasing the inclusiveness of the STEM departments at SJU and retention for majors. Variations between outcomes for students of differing socioeconomic backgrounds in entering STEM careers has been shown to be more related to degree completion than initial interest, suggesting the need for greater attention to supporting STEM majors from non-dominant groups throughout their college years. While financial barriers can be addressed through scholarship programs, they are not sufficient for ensuring success and addressing challenges such as lack of a sense of belonging in university cultures that tend to privilege the experiences of high-income, White students (Stephens et al. 2014). The sense of alienation can be particularly pronounced in the fields of math and science for students of color (Reyes, 2011) and for students from lower income backgrounds who can experience disconnection due to perceptions of a non-communal science culture (Allen et al., 2015).

Several studies have focused on approaches that may be successful in reducing disparities in sense of membership in universities. Stephens et al. (2014) argue that for success in college, students from low-income backgrounds need to experience a sense of perceiving "fit," which can occur through experiences that affirm that college is for people like themselves, such as having a voice in the community, participation in strong peer networks, and access to role models. Other studies have focused specifically on STEM fields. For example, Chemers, Hu & Garcia (2001) argue for the importance of fostering self-efficacy, which is essential for commitment to science careers for underrepresented students. Supporting the importance of mentoring, Kim and Sax (2001) describe that student/faculty interaction "is one of the key college experiences associated with student development" (p. 437). In addition, participation in undergraduate research has a strong positive impact on retention (Eagan et al., 2013).

In Fall 2020, the new program will include a suite of student support and engagement mechanisms designed to increase recruitment into STEM fields of study, provide scholarships to low-income and/or first generation college students, and provide faculty and peer mentoring. Some possibilities that I am considering in addressing the vexation:

1. In my research, I keep the focus on analyzing the experiences of students and developing manuscripts and reports. Results would inform the program, but the recommendations in reports would be described generally (for example, "when ____ was a part of mentoring, students were more likely to take academic risks.). A benefit is that faculty may not feel scrutinized by a colleague, and my service and research roles are somewhat separated. However, one issue is that even if reports are general, specific incidents would be described in any emerging manuscripts, therefore this approach may not still not effectively maintain anonymity or boundaries, though that is the intention.
2. Allow the emerging research to inform the program on a more ongoing basis, rather than just through internal reports and research manuscripts. Faculty mentors and students would understand from the beginning that the research is focused on improvement, and faculty members would be asked to be involved as research participants. The focus of the research could partly be on the process of change. However, one big problem is confidentiality. For example, if students' experiences are used to inform the program, students' anonymity, and perhaps sense of freedom to describe their experiences, is reduced. In addition, if faculty are participants in the study, with me in a researcher role, they may feel constrained in their interactions, which may make both the program and research less effective.
3. Along the lines of option #2, I could use cogenerative dialogues as an approach. For example, as part of the study, students and faculty could meet and discuss classroom events with the goal of improving the classroom environment for students from marginalized backgrounds. One issue is that not all faculty would be interested, nor would there be time to engage all STEM faculty in cogenerative dialogues. Another issue is that I believe this approach would only work in considering the students' experiences in courses or labs. This approach would not work to study the impacts of one-on-one mentoring relationships. Cogenerative dialogues therefore would only be a small part of the research, and I would still need to develop ways of addressing issues that may emerge in mentoring.

Vexation

Since the 19th century, science educators have called for reform of traditional science classroom teaching, as a result of two major concerns: First, traditional science instruction is fact based, requiring students to memorize facts, listen to lectures, and focus on the textbook as an authority (Schwab, 1962). In science classrooms, a "focus on standards, achievement, and outcomes is currently…encouraged (if not mandated in many cases)" and leads to a "content coverage approach to science teaching" that has failed to represent the best ways for students to learn in science while also doing very little to encourage participation in science careers (Yerrick & Gilbert, 2011, p. 67). Accordingly, students have waded through an ontological soup of facts, theories, and laws served to them by textbooks and teachers. As long ago as 1913, a dissatisfied John Dewey stated that "pupils learn a 'science' instead of learning the scientific way of treating the familiar material of ordinary experience" (1913, p. 257).

The second concern is that traditional science teaching marginalizes certain groups of students weakening their participation in advanced studies or careers in science. These gaps in participation in science outcomes generally are situated around racial, ethnic, cultural, linguistic, or income groups as well as around gender (Barton, 2001; Blickenstaff, 2005; Lee & Buxton, 2010).

Today, many science educators are still unconvinced that a fact based approach to science, an instructional choice to focus on what we know, will help students learn the proper "scientific habits of mind" or the scientific literacy necessary to navigate society (Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002). Instead, science educators have proposed that teachers adopt a more epistemological style of instruction—that is, an approach based on the study of the nature of knowledge, how it is constructed, and how we know what we know (Driver et al., 2000; Duschl & Osborne, 2002).. A classroom committed to an epistemological approach to science education is more likely to have students engaging in a co-construction of scientific knowledge and a process of inquiry.

Recent reforms around science teaching have been idealized as incorporating inquiry, a more dialogic process to exploring content, and adopting a more constructivist approach to learning science than traditional science instruction (Yerrick & Gilbert, 2011). Studies proposing this approach ask students to have these conversations in small groups, where students can debate and critique each other's scientific findings (Osborne, Erduran, & Simon, 2004). The reform-based classroom, though rich with discussion, may also be rife with contention or strained discourse, as both Sandoval (2003) and Cohen and Lotan (1995) have found argumentation and other peer-to-peer conversations pose difficulties for students (Kuhn, Iordanou, Pease, & Wirkala, 2008). Researchers have found various causes for the difficulties students face in group interactions: inability to critique others' ideas (Sandoval, 2003; Sampson & Clark, 2008), lack of social coordination skills (e.g., eye contact, turn taking, vocal tone, etc., Barron, 2003), domination of group socially and academically by certain students (Dembo & McAuliffe, 1987), and the free rider effect (Kuhn, 2015).

According to Cohen (1990), group work for students is not a neutral zone. Rather students enter group situations with status differences which impact the social interaction. Per Lotan (1995), status refers to the amount of influence and power a student has within the classroom. Cohen and Lotan describe status characteristics as "socially evaluated attributes of individuals for which it is generally believed that it is better to be in the high state than the low state" (1995, p. 101). Students working together as a group assign status characteristics to individual members based on diffuse traits (i.e. gender, race, or ethnicity), academic traits (i.e. perceived ability in math, reading, science, etc.), or specific traits (i.e. occupation, skill and training) (Cohen & Lotan, 1995).

Most important is the idea that these expectations are based on perceived and not actual individual ability. According to Cohen (1990), these differences in expectation act as a self-fulfilling prophecy as students' behaviors align with their perceived status characteristic. Within the classroom, these new status expectations begin to shape and affect student interactions creating a hierarchy of participation. Cohen (1990) warns that the participation and effort of low-status students becomes depressed (and can result in misbehavior) if status differences are left unchecked.

If science educators encourage students to critique others' and defend their own ideas, there will be a need to develop a variety of supports that increase successful participation in group interactions riddled with status differences and social inequity. Students in classrooms rich in dialogue have more success when they have emotional and social competency (Haynes, Ben-Avie, & Ensign, 2003). Supporting students to gain social and emotional competence can take on various forms: social emotional learning curriculum, professional developments for groupwork design, sentence starters, and group roles amongst other. These structures have had measures of success in the classroom. In addition to these strategies, I argue that making space for off-task talk may provide opportunities to build relationships necessary to address status differences during groupwork.

Venture

My goal is to problematize/re-frame traditional views off-task talk in an academic space as superfluous and detrimental to meaningful discourse for learning. Instead, I argue for the potential of off-task talk to facilitate relationship building and equitable learning interactions in student-led learning spaces. Equitable interactions during groupwork are linked to increased learning among all members during a group task (Cohen 1994). Thus, equity in quality and quantity of talk becomes the goal for groupwork. Indeed, I argue that equity in group interactions requires justice that is socially constructed, the flattening of social hierarchy, and includes three key features: student voice, visibility (of all students), and student authority.

These arguments stem from research conducted during group interactions between middle and high school students from a suburban California city are used to highlight these features. I used sociolinguistic discourse analysis to analyze students' voice in group interactions which were video recorded. Images from video recorded data, event maps from student dialogue, and data from student interviews are used to examine the role of visibility, voice, and authority in creating equitable interactions in groupwork. The analysis of the group interactions confirmed standard findings within the groupwork literature: overall, there is an imbalance in the kinds of talk as well as the amount of talk students engaged in with their peers. That is, students that are deemed as being popular and smart by their peers express their voice more than those students who do not have high academic and social status amongst their peers (Cohen & Lotan, 1995).

Implications from this study point to equity as a process--a transformative social process where students use their words (reflection + action) (Freire 2000) to shift inequities and increase communication in science. Equity as a process does not mean the absence of inequity but that students use their words to address inequity when it arises to transform the space. I highlight the transformative power students' words have and their ability to create equity through voice, visibility, and agency in student-led spaces. teachers can create the classroom conditions necessary to cultivate productive and equitable talk in science classrooms.

Off-task talk is one form of student talk that can bridge the gap between high status and low status students. Although most teachers view this form of talk as unproductive, Gutierrez argues that students often create counter-spaces where students talk without the teacher being present in ways and forms that subvert the norms of classroom talk. These counter-spaces in a learning environment are where two interactional patterns intersects thus creating potential for students to shape what counts as learning and to engage in interactions that are more authentic (Gutierrez, Baquedano-Lopez & Turner, 1997; Gutierrez, Rymes, & Larson, 1995).

In my data, during groupwork students often engaged in off-task talk during the learning activity. This off-task talk allowed students to use norms beyond classroom rules to shift hierarchical behavior during science labs more equitable for the low status students. Additionally, students made personal connections with peers that they otherwise did not interact with during off-task in the science lab. Later on, the high status student was able to persuade a lower status student of their value in a learning activity when they were ready to quit. These scenarios are just a couple that highlight the ways in which off-task talk played a role in building relationships between students that led to important academic accomplishments.

These findings are the basis of a conceptual paper I am writing. While I have various data points that I can use to illustrate the connection between off-task talk and future academic progress and equitable interactions, I wonder how best to write the implications and next steps for teachers, teacher educators, and administrators—as the educational leaders of the school site and at times the heart of change for classroom learning. For certainly, not all off-task talk leads to equity or content learning but there is value in making space for it.

My questions for the incubation time …

1. Do you buy this argument for off-task talk? If so, what do you find compelling? If not, what more would you need to see this as having instructional value?
2. Are you aware of other scholars who discuss off-task talk as valuable for classroom learning?
3. How might teachers, teacher educators, and administrators, make space for off-task talk in a classroom environment? Should it be structured in the learning activity (explicitly or outright), or more of an invisible commitment of the teacher?

Greses Pérez, *Stanford University*

Vexation

Diversity is essential to good engineering design (Layne, & Arenberg, 2002). Take this for an example: in 2012, engineers at YouTube ran into a stunning phenomenon. After releasing a mobile app to upload videos from phones, about 10% of the uploaded content was upside-down. When troubleshooting, the team found something unexpected: Left-handed people pick up their phones differently from right-handed people, leading to upside-down videos. The exclusively right-handed team did not consider this possibility (Manjoo, 2014). In the aftermath, Brian Welle, Google's Director of People Analytics, summed up the findings, "If we have engineers that reflect our users, we are going to better understand the needs of people and solve problems that nobody has asked before." As suggested in previous scholarship (Schiebinger, 2014a, 2014b; Badran, 2007; Hong, & Page, 2004), Welle's view reflects the potential of diverse engineering teams in creating better solutions. If engineering is to drive innovation, we need to start by asking, "Who is sited at the design table?" Though hand dominance is an important feature of human diversity, other features are much more complicated and rich in diversity, especially language. In the US, the field of engineering lacks diversity and makes poor use of talent (Grimson, & Grimson, 2019). About 35% of the population identifies as an ethnic, racial or linguistic minority and more than half as female (U.S. Census Bureau, 2018). Yet, women and underrepresented minorities (URM) make up less than 15% of engineers in the workforce (NSF, 2015). Their inclusion in engineering is not only an issue of social justice, but also an economic imperative. If we don't act, we risk losing economic and intellectual opportunities (Chubin, May, & Babco, 2005). The diversity problems in engineering range from who is at the engineering table to what problems are getting solved through engineering practice.

Students' diverse backgrounds are often an undervalued resource in technical fields. Before coming to Stanford, I was a bilingual math and science teacher in a diverse school where 90% of the students came from families living below the poverty line. Every single day taught me that we all grow up differently. We develop different tools for how we communicate what we believe, who we are, and what we think. The tools we developed within our communities are part of a larger repertoire of cognitive resources link to language and culture. Think about the potential of this diversity, not only for engineering, but also for our society. Yet, schools are institutions that leave little freedom to our students to do things differently. Schools may discourage students from using some of their resources, such as language, experiences, and backgrounds. Through reinforcing norms, such as language separation in classrooms, schools limit the pool of resources students can draw from to engage in engineering and science, even though these resources may be powerful and important to learners (Brown, Cooks, & Cross, 2016). Unfortunately, these norms signal to students that they are unworthy to be scientists and engineers and may discourage them from pursuing careers in technical fields. As educational leaders, we need to ensure that all people have the possibility to be heard and to contribute. If we welcome learners' ways of being in the world, we may afford them the opportunity to see themselves in and navigate (García, & Wei, 2013; Wei, 2017) the fields of science and engineering. The failure of developed societies to engage young people, particularly women and minorities in pursuing careers in science and engineering, points to the need to (a) develop a better understanding of how to use human diversity as an asset; and (b) create a new vision of how to engage in engineering design in a globalized and interconnected society. I believe that virtual reality (VR) represents a powerful tool in this effort.

Many of you may be asking, why VR? Previous scholarship conducted by the ***Science and the City Research Team*** at Stanford, on the potential of these technologies for teaching and learning, suggest that VR environments *that incorporate user's diverse backgrounds* may influence students' perceptions about the content and who can become a scientist or engineer (Brown, Pérez, Ribay, Boda, & Wilsey (in review); Pérez, Brown, Boda, Ribay, Wilsey, 2019). Furthermore, students connected basic concepts taught through VR with larger issues of social justice in their communities and elsewhere. Current VR scholarship has yet to take advantages of the opportunities to connect students' lived experiences, the content and broader sociopolitical issues. The VR instructional tools that I hope to develop will build on these previous findings and students' gained awareness. These virtual environments will reflect and draw on participants' lived experiences to inspire them a) to see themselves in engineering and b) take into consideration their background when engineering solutions to real-world problems.

Venture

To address the problem described in the previous section, I propose an interdisciplinary study investigating *the affordances of virtual reality (VR) for engineering design in K-12th settings. In addition, I seek to understand students' response to different linguistically environments when engaging in engineering design*. The linguistic environments are: (a) doing engineering in one language, or (b) doing engineering with opportunities to draw on any linguistic resource. This project combines broader research perspectives and methods from applied linguistics, engineering education and science education.

In the context of this study, diversity is defined as the myriad of factors that influence human identity. Some of these factors include gender, linguistic background, ethnicity, race, cultural background, socioeconomic status, and competencies. In this study, I will investigate the following questions:

1. How do students respond to doing engineering in one language only?
2. How do students respond to doing engineering in multilingual contexts?
3. In the case that there is a difference, how, and to what extent, do students' responses differ by linguistic condition?

To answer the first two questions about the impact of linguistic diversity and inclusive environments, 32 students will be clustered into groups of four. Entering a VR platform, participants will be introduced to problems like the Midwest Floods (Atman, Yasuhara, Adams, Barker, Turns, & Rhone, 2008; Bogusch, Turns, & Atman, 2000; Rieken, 2017; Adams, Turns, & Atman, 2003). The Midwest Flood Problem prompt is as following: "In the past, the Midwest has experienced massive flooding of the Mississippi River. What factors would you take into account in designing a retaining wall system for the Mississippi?" All teams will experience two different virtual realities environments with distinct linguistic affordances: restrictive linguistic boundaries (English-only setting), and fluid boundaries (mix of English and Spanish setting). Based on psychology methods, the teams will experience these contexts as they rotate through each of the conditions (Rosenthal, & Rosnow, 1991), enabling comparisons of the affordances of each condition per team type. To answer the third question, a retrospective interview using the replay of video data will be conducted (Lahlou, Le Bellu, & Boesen-Mariani, 2015). This procedure offers a better understanding of the activity. It also provides evidence of the elements that may have contributed to differences in performance by condition.

This research seeks to support educational leaders in helping diverse students to be heard and to contribute, thus encouraging them to pursue engineering and science careers. Previous research has shown that diverse teams outperform homogenous groups. However, we currently perform poorly in attracting people from diverse backgrounds to the engineering profession. Emerging technologies such as virtual reality opens the possibility of creating inclusive spaces in which learners can utilize all of their linguistic resources. As a researcher who studies how diversity influences engineering design in virtual reality environments, I want to lay the groundwork for others interested in equity and innovation in engineering and science.

My venture now launches from the idea that there is a connection between language and cognition. I want to begin to think about meaningful, substantive research on this area. This raises a few questions:

1) If and how have you ever considered the role of language and cognition?
   - How do you define them?
2) What kinds of evidence will be compelling about establishing the link between language and cognition?
   - Although I have a potential study design, what approaches to inquiry and data would be productive?
3) What pedagogical elements could contribute to differences in students' responses?
4) What factors may prime students to respond differently in the distinct language conditions?
   - How could I make the connection between cognition and language visible?

I hope to pursue these questions at Crossroads. With the extended community of Crossroads, I want to investigate possible meaningful, effective, and productive avenues to develop these ideas.

Engaging in Professional Development Research that is Justice-Centered and Teacher-Centered

Kathryn Ribay, *Stanford University*

Vexation

A few years ago, I attended a panel where current science teachers shared what they wanted from education researchers. They discussed the issues that were most pressing in their practice and questions they wanted to see research about. As we left the panel, my fellow education researchers seemed unimpressed.

> "*That was kind of a waste of time*," one said.
>
> "*What they were asking weren't research questions. And some of what they were asking for already exists, shouldn't they know that? This isn't how research works*," added another.

Since then, I have been wondering—why isn't it? Why do we diminish the questions that teachers are asking as less important or less valid then those of education researchers? My vexation is that too often the flow of information between educational research and K-12 teachers is regarded as a unidirectional pathway, where the focus is on getting novel research findings out to teachers rather than considering how the expertise of science teachers can inform research. In my work, I study how chemistry teachers conceptualize and act on theories of social justice in their teaching. The teachers I work with walk into classrooms every day and see the impacts of societal injustice in the lives of the students they teach. They are uniquely positioned to understand the immediacy of the needs of young people. By primarily positioning teachers as objects and recipients of research, I worry that education research loses key perspectives that could aid in understanding teaching and learning. In discussing social justice in the classroom, this distinction becomes even more critical, as developing pre-determined equitable practices to be taken up by teachers is a radically different approach from developing justice-centered educators who lead in innovative ways in their schools and communities. In this vexation and venture, I hope to consider how to support the latter scenario.

Racism is a "foundational practice of science teaching" (Sheth, 2018), and therefore, centering justice in the science classroom requires grappling with past and current instantiations of racism in science. While this has been less deeply explored in chemistry than in some other sciences, there is a growing body of work considering justice-centered chemistry education. Morales-Doyle (2017) found that when students are given the opportunity to engage with chemistry in a community-based, praxis-oriented way, they took on a "transformative intellectual" (p. 1034) identity, able to analyze and act upon complex scientific social issues. Additionally, Sjöström & Talanquer (2014) argue that chemistry instruction should also requires question the ways that scientific methods and discoveries are framed in the curriculum and incorporate a critical analysis of how that chemistry has caused harm as well as progress.

There are multiple forms of inequities that impact science classrooms, from the policies and environmental concerns that affect some students more than others (Calabrese Barton, 2002) to status differences within the classroom and curricular content that reifies dominant ideologies of Western science and scientists (Braaten & Sheth, 2017). Incorporating such ideas about equity and justice into chemistry teaching requires a critical examination of both the classroom and the system surrounding it (Bianchini, Dwyer, Brenner, & Wearly, 2015). This raises the question, what do we lose when we take a one-size-fits-all approach to equity and social justice by messaging practices to teachers without drawing on their knowledge of their subject, practice, and context? What is the role of teacher leadership in drawing on that knowledge?

In thinking about teacher leadership, I draw primarily on the definition articulated by Holland, Eckert, and Allen (2014): "teacher leadership encompasses the practices through which teachers—individually or collectively—influence colleagues, principals, policy makers, and other potential stakeholders to improve teaching and learning" (p. 435). Extending this definition, teacher leaders propose and execute new ideas, influencing not only their own colleagues, but also "other potential stakeholders" such as education researchers. In the summers of 2017 and 2018, I co-facilitated a summer workshop for chemistry teachers looking to bring social justice into their classrooms, and I am now thinking about how to move from designing a one-shot weekend workshop to supporting an ongoing network of dedicated teachers. My vexation, then, is how to provide avenues to support the development of this type of teacher leadership in bringing a social justice focus to chemistry teaching.

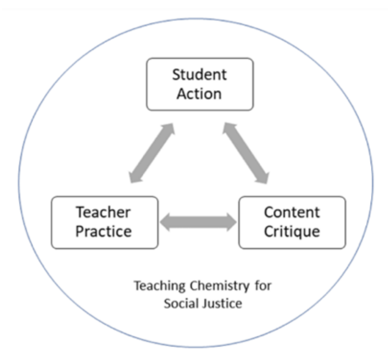
Venture

As I enter into my dissertation research, I am contemplating how to put those values into practice. What does it look like to conduct my own research from a stance that values the expertise of classroom teachers? Currently, I am facilitating and studying a year-long professional learning community for social-justice focused chemistry teachers that is a continuation of the initial workshop. While researcher-teacher learning networks have been shown to shift teachers' understandings of racism, equity, and justice (Johnson, 2011), traversing the hierarchies and histories of researcher/teacher partnerships is not an easy task. I am hoping to push the bounds of this collaboration to center the contributions of teachers to the construction of knowledge within the group while facilitating an experience that is practically useful as they work to address the needs of their students.

This study works with a small group of four teachers, all from different schools. Therefore, they are each bringing the unique expertise and challenges formed from their school sites The small size of the group lends itself to the development of personal relationships and trust that have been shown to be critical for navigating potentially damaging tensions within professional development spaces (Finkelstein, Jaber, & Dini, 2019).

I have based the initial phases of the PLC, in which teachers set guiding goals for the year, on the "Teaching Chemistry for Social Justice" framework that I developed as part of an earlier project. It posits that to integrate social justice, chemistry teachers need to simultaneously consider:

1) How their teaching strategies impact equity within the classroom
2) How students are able to build from their chemistry knowledge to inform socially just actions
3) How to engage students in critiques of racist, sexist history and present embedded in the development and practice of science



However, going back to my initial vexation, I want to avoid equating success with uptake of my existing framework. As teachers work within the framework to set goals for themselves, I anticipate that they will run with the ideas, constructing their own ways of thinking about social justice in chemistry and asking questions that push the group in new directions. After all, if I want to claim that teachers' questions are valuable to research, I need to model that in my own work. While I will be engaging in self-study alongside the K12 teachers, focusing on my own teaching of a science methods teacher education course, hierarchies around institutional roles and knowledge sources are deeply ingrained—simply saying that we are breaking out of those roles is not enough to make it so. In their analysis of an unsuccessful university-school partnership PD, Carlone and Webb (2006) note that "intentions to challenge history are not enough to actually promote transformative meanings" (p. 553). What are some concrete ways that I could move beyond intentions to actually creating a collaboration?

While my goal is to recognize the expertise of the teachers in this project, I do still believe that educational research plays a role in improving teaching and learning. So, I wonder how best to draw on the complementary roles of researcher and teacher. As a full-time academic, I have a portion of my time set aside for research, while the many demands on teachers' time leave little time for research and developing new materials. I have access to current research and can share findings from that research with teachers in the group. At the same time, teachers have the experiential knowledge of the injustices they see in their classrooms, as well as an understanding of how policy initiatives are being implemented on the ground. That perspective is a valuable check on researchers who are no longer in K12 classrooms.

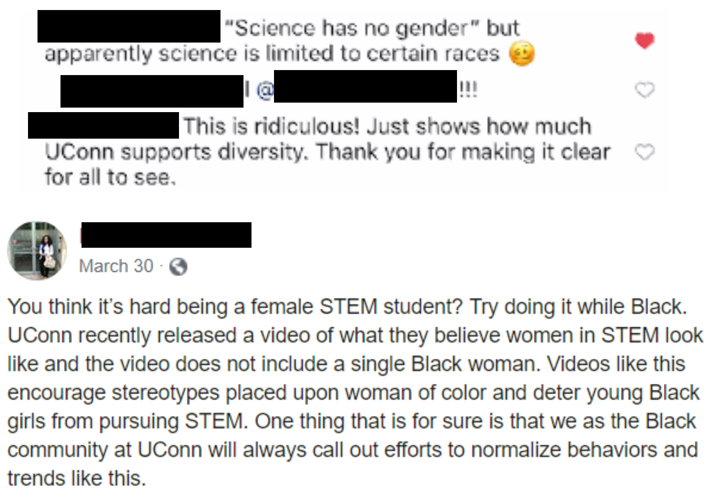
If I am going to consider teacher expertise in the research process, I want to also consider teacher expertise in the research distribution process. In part, this might look like shifting from solely thinking about research findings as the "outcome" to be disseminated, to thinking about how to support teachers in sharing what they are learning with their own schools and networks. I shouldn't be the only person coming out of the process with new ideas—if teachers are generating their own ideas and understanding of social justice in chemistry classrooms, how should that be shared in a way that recognizes the teachers' ownership of that knowledge? How can I can center the expertise—about practice and the equity issues in their settings—of the teachers? I wonder how this well-intentioned effort simply reinforce the status quo; how can I work against that?

"This is What Women in STEM Look Like": Microaggressions and Feelings of Erasure in Visual Content/Media

Stephany Santos, *University of Connecticut*

Vexation

Our University's communication department released a short video on their Instagram platform titled "This is what women in STEM look like." The one-minute clip featured 12 women, 8 of which appeared White, 2 appearing South Asian, and 2 appearing Hispanic/Latina. None of the women featured in the video had complexions darker than rapper Cardi B. None of the women had hair curlier than singer Jennifer Lopez's waves. None of the women had curvy or "above average figures." None of the women exhibited physical disabilities. The lack of diversity was glaring in the video, prompting a slew of comments from our undergraduate population (see images below).



Apart from feelings of erasure, Black women in particular continue to experience the "double bind" of race and gender marginalization within STEM culture. "Issues around race, class and gender often make the learning environment hostile and unwelcoming, particularly in STEM fields. Aspects of the hostility include racial microaggressions, which are subtle messages that are insulting or demeaning to people of color. Research suggests hostile campus climates are associated with students of color leaving STEM fields before graduating" (Cross et al., 2017).

Today, classroom instruction, extracurricular enrichment, and out-of-class experiences are all influenced and shaped by the inclusion of technology, digital media, and visual arts and expression. With increased use of visuals in learning, promotion, and/or personal expression, there are increased incidences of microaggressions occurring. In the aforementioned example with the "This is What Women in STEM Look Like" video, viewers that did not identify with the women in the video experienced a micro-invalidation, such that if they do not fit the proposed definition, they aren't seen or acknowledged as a STEM person.

The creators of the video apologized and acknowledged this was not the intent, but as with the majority of microaggressions, though not intended, the damage was done. In this case, the audience was not just UConn students, but it was a public video that the greater community could view, including K-12 students. Thus, this one video can fuel feelings of erasure and imposter syndrome in current Black women (and others not included in the video), as well as rejection or exclusion for young students potentially aspiring to be women in STEM.

As educators, at any age/grade level, we empower our students to express themselves through varying degrees of visual media. **Although students' technological capability and artistic expression is continuously improving, it seems there is not a systematic approach to teaching students to have a STEMinist spirit, such that when creating any form of visual expression, they employ multi-faceted, culturally-conscious and responsible checks or standards prior to publication that promote equitable expressions of all.**

Venture

I've begun to collate different forms of "Quality Control" that could be implemented:

Area 1 – Imagery: When I create presentations and I think of an image I want to put in, I turn to Google. It is very easy to select one of the first few images that are returned in the search. Oftentimes these are monochromatic and not diverse. I make it a personal mission to keep scrolling until I find a person of color, a woman, etc. because representation truly matters in visual media and messaging. I make it a personal mission to span the multiple facets of diversity including:

- skin tone (recognizing colorism within race/ethnicity as well);
- hair texture and length;
- ability (trying to select people with visible physical disabilities or impairments);
- size (not just selecting skinny / "average" sized people but covering many body types);
- gender norms (i.e. if representing women, looking for a Rihanna, a Young MA, a Ruby Rose, a Queen Latifah, a Rhonda Rousey, a Laverne Cox etc. Because femininity and womanhood are not interchangeable, and LGBTQIA+ individuals can still identify as being women);
- religious expression (i.e. women who wear the hijab);

Area 2 – Words: Blanket statements such as "this is what women in STEM look like" are exclusive by design. Any statement should be questioned such as: If I were a [insert marginalized group here] do I identify with this? Do I feel included? Do the accompanying images support the text and message? How can my words be rephrased so that it doesn't seem like I am creating a definition (i.e. this is women in STEM), but rather an array of examples with room for expansion (i.e. I am a woman in STEM)?

I've also thought of how to include ***conversations about bias, empathy and action*** with students in the classroom. Bias says: "I didn't realize that east Asian women were missing." Empathy says: "I (as a person with privilege) will never understand what it is like to feel invisible. But I hear you." Action says: "in order to learn from our biases and enact our empathy, here is what I will do to prevent this from happening again."

Open Questions:

1. In a STEM-content heavy curriculum, how can I raise the emotions and experiences felt by marginalized and/or underrepresented students to inform and motivate a change in our visual expression (presentations, videos, flyers, etc.).
2. Can I create a rubric for cultural competency for class deliverables? If so, what and how can I measure?
3. How do I measure or quantify success in an intervention?
4. If I can create a rubric and find success after implementing in a course, how can I effectively collaborate and/or share this with pre-service teacher training and encourage others to take lead in this effort as well?

I have approached my university to implement these sorts of quality control measures and training for undergraduate leaders in official organizations through their mandatory training workshops. I would love to have a broader reach.

Supplying Equity Scripts to Preservice STEM Teachers

John Settlage, *UConn – Avery Point*

Vexation

Overcoming educational disparities is a central feature of my accelerated STEM Teacher Preparation program. Enrollees move through their eleven months as a cohort, as we offer coordinated experiences that sustain individual and collective growth. There are countless mechanisms for the future teachers to sort through uncomfortable situations -- things they witness, conversations they overhear, and wisdom they receive. As their advisor, I can offer perspectives when they encounter discriminatory perspectives and it's not just me: instructors are equally attuned to helping make sense when their emerging equity orientations collide with less enlightened people and perspectives. Some cohorts are better at helping one another process deficit talk. As the future STEM teachers became more aware and awakened, they are able to confront the dissolution of their privileged upbringings and begin constructing new ways of imagining who they are becoming as teachers in a multicultural society. This is not easy and not everyone ends up in the same place by the time they graduate (Milner, 2010). They all undergo changes even if they don't end up at the same point along an equity continuum. However, I am confident they enter classrooms with inclusive views and prepared to think about their students in generous ways. But what if that is not enough?

My concern is whether the program provides these energized teachers with sufficient voice to advance equity discourses once they leave my immediate care. I worry that when they encounter bias, racism, or privilege in their schools their thoughts will only allow them to appreciate what they hear. Otherwise they will remain mute. Otherwise, we haven't given them tools to apply this knowledge. They deserve to know how to act and to speak when those situations arise. The core of my concern relates to the dangers of remaining silent during discriminatory talk. This is a something that troubles me because it feels simpler and safer for me not to say something when I hear the wrong thing. I would like to believe my advisees could do better than me – if I gave them appropriate tools to do so.

Not speaking up can be viewed by the speaker as having an ally with their ideas. By not commenting or complaining, this could be interpreted as an endorsement of the utterances. Further, from the perspective of others in such situations (especially students but peers as well) such silence might signal an alignment with those words and beliefs. Given these dangers, not responding could permanently tarnish my advisees' reputations. My preference would be for them to have tools they could deploy. Since they are new to their workplace and novices in their profession, I feel it's imperative to infuse ways of speaking so my alumni are able to participate in high-stakes conversations within their schools. Otherwise, their generous beliefs and good intentions will remain inert and reinforce majoritarian narratives.

Vexation

My uneasiness about teacher beliefs that aren't actionable was more tangible when I became aware of bystander training. By and large, these interventions are intended to prompt action when people witness sexual harassment or bullying behavior. My understanding is that such interventions are supposed to disrupt in the short-term and potentially serve as a starting point for long-term changes. At this very moment, I am less focused on gendered interactions and instead concerned about potential educational incidents centered around racial, ethnic, socio-economic, English fluency, and immigrant issues. The hope is to develop an intervention to deliberately prepare my future STEM teacher to determine how to act when someone (especially a fellow educator) makes biased allusions or remarks. In effect, my dream is to instill in my advisees carefully developed scripts they can use in these inevitable situations.

Two sources have helped advance my thinking. One was a literature research review on bystander anti-racism (Nelson, Dunn, & Paradies, 2011) containing a chart showing potential enabler and obstacles to taking action (see below). The other was a model they favored (called CPR) describing response possibilities when confronting prejudice (Ashburn-Nardo, Morris, & Goodwin, 2008). This included a nice decision tree to assess a situation and for deciding whether action is necessary. Unfortunately, this material offers few specifics: Step 5 indicates one should take action.

ENABLERS of bystander action
- Knowledge of what constitutes racism
- Awareness of harm caused by racism
- Perception of responsibility to intervene
- Perceived ability to intervene–skills: optimism, self and/or collective efficacy
- Desire to educate perpetrator
- Affective responses to racism: empathy, anger, disapproval, etc.
- Anti-racist social norms

OBSTACLES to bystander action
- Exclusive group identity
- Fear of violence or vilification, being targeted by perpetrator
- Perception that action would be ineffective
- Lack of knowledge about how to intervene
- Gender role prescriptions for women
- Impression management, preserving interpersonal relations
- Desire to avoid conflict
- Freedom of speech / anti-political correctness
- Social norms that are tolerant of racism

The other potential helpful source comes from medical education discussion about “illness scripts” — knowledge structures expert doctors use when listening to a patient (Charlin, Boshuizen, Custers, & Feltovich, 2007). While this use of “script” differs from what I’m seeking, I appreciated the indications that before speaking it is important to engage in diagnosis. I interpret that as: (a) hearing as recognizing key features, (b) filtering and sorting information, (c) hypothesizing and assessing, and (d) producing a reasoned response. Just as with the clinician, my hope is to support my future STEM teachers to deftly notice what is being said, attend to underlying meanings, and determine whether something needs to be said or done. I suspect my new teachers are often struck mute by inappropriate comments made by other adults. The concern is that the resulting silence may be misinterpreted as agreeing and aligning with the bigoted view. This can shape others’ views of my students and pigeon-hole them, not based on intentions but instead upon the absence of actions.

Much more recently, my ambition to provide scripts has matured into a notion about collecting information under the guise of a quasi-research study. This is only the germ of an idea so I’m receptive to your input. First, I will contact former students who are now teachers and who I believe left our program with very strong equity orientations and are not race evasive (Jupp, Berry, Lensmire, (2016). I will ask them to describe adult-to-adult interactions they witnessed or experienced in their workplaces where one individual was speaking in a bigoted, biased, \ or discriminatory fashion. I’m thinking of actually prompted them to recall such incidents where they felt dumbstruck. As they share their stories, I will ask them to detail the particular situations, explain the response that occurred, and offer them to describe how this dispute might have gone differently if someone had spoken up. Each story would be developed into a case I would write and then verified for accuracy by my former advisees. I could couch all of this as a request to provide real-life examples for future preservice STEM teachers who would benefit from these stories.

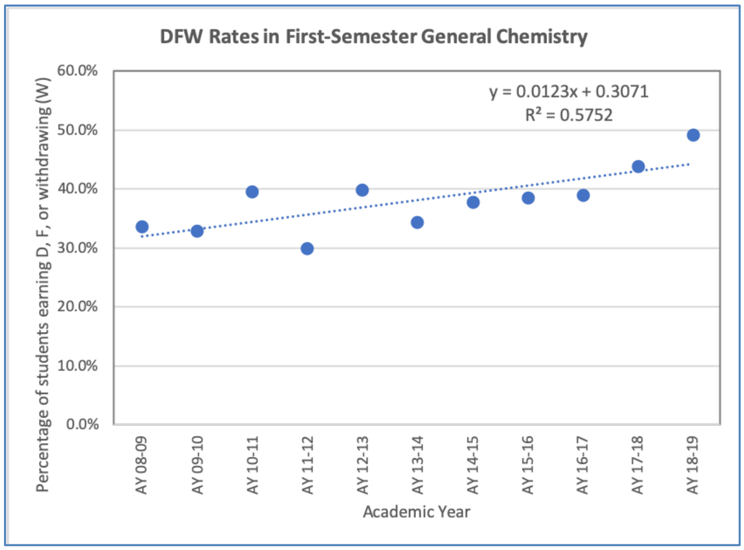
Next, I would recruit experts who could offer advice from their informed perspectives. These experts would be academics or school-based practitioners who are knowledgeable and articulate about social justice and attuned to the challenges of preparing future teachers to be culturally responsive professionals. When presented with select cases, each expert would be invited to offer a frame for the story. They will also be asked to offer whether there was evidence of bigotry, deficit-reasoning, colorblindness, bias, etc. They would be invited to interpret the circumstances describe in the case. They would then be asked to offer advice about what could have said or done as a substitute for acquiescent silence. I am optimistic that this approach will surface useful scripts and instructional resources. Thoughts?!

Students Who Tend to Fail University General Chemistry: What's Right with Them?

Hannah Sevian, *University of Massachusetts Boston*

Vexation

My university has a problem common to most universities in the US: about half of all our students bomb first-semester general chemistry. This is a problem because most STEM majors require two semesters of general chemistry, and most 200-level STEM and nursing courses have general chemistry as a pre-requisite. For this reason, it's called a gateway course. My university enrolls about 17,000 students, more than half of whom don't speak English as their first language and are the first in their families to go to college, and about two-thirds of whom transfer in from two-year colleges. We are the only majority-minority university in New England, and the only public university in Boston. The literature abounds with explanations of what our students lack (Bird, 2010; Chan & Bauer, 2014; Lewis & Lewis, 2007; Shibley, Milakofsky, Bender, & Patterson, 2003; Tai, Sadler, & Loehr, 2005), and some researchers concentrate efforts on demonstrating how and why this doesn't prove that non-white, first-generation college-goers, and non-native English speakers are incapable students (Hoffman & Lowitzki, 2005; Zwick & Sklar, 2005). A point on which many can agree is that if we could address the chemistry problem at universities like mine, we could make novel progress in addressing issues of equity and access to STEM professions and other power structures.



My university's problem steadily gets worse. The tuition is the same whether you take 12 credits or 17, so most students take 17 credits, while they also work full-time, live at home, and support siblings, parents, and children. We've gradually lost funding from the state legislature, and since we already have incredibly low salaries and a barebones infrastructure, the only way the university can stay afloat is to grow and to raise tuition. Since I started here in 2001, we have grown from 8,000 to 17,000 students, while the tuition has increased. For the past two years, the administration has strived to appeal more to first-time freshmen, expanding upon (some say diminishing) the mission of this university to serve the urban place in which it is embedded. While the percentage of non-white students has increased, from 40% to 65%, the average age of undergraduates has decreased, from 27 to 24. Our students in general chemistry are younger, and fewer of them have developed study habits elsewhere. Instead, they are developing them here. The graph shows how this all plays out in first-semester general chemistry (the fraction of students earning a D or F or Withdrawing from the course, or DFW rate, is measured because these are the students who cannot progress to the second-semester general chemistry course, which requires a C- or higher in first-semester).

While my university is not unique in this perpetual problem, the reasons it happens here may not be the same as at more traditional universities that educate more of the university graduates who wind up in STEM professions in the US. Meanwhile, the majority of funded research on this happens at well-funded institutions, which are not where most students like mine go to school. What if the reasons why the problem occurs are not the same everywhere (less interesting), and what if the ways that our students succeed in chemistry are different than for students at more traditional universities (more interesting)? Could we build a model for changing the landscape?

Coincidentally, my university's administration is very interested in improving retention of first-time freshmen. It would increase the university's six-year graduation rate (a major statistic by which universities are compared) and it is more costly to recruit new students to matriculate than to keep the ones we already have. Due to our shared interest in addressing the DFW problem, the university is letting me start a supplemental chemistry course for students in first-semester general chemistry who are at risk of DFWing.

Venture

I want to concentrate on how, when, and why these students **are** capable. The undergraduate general chemistry curriculum has barely changed in 75 years, and most faculty who teach it value knowing canonical facts and performing canonical algorithms. Meanwhile, I have built my research around studying how students learn and use chemical thinking while teachers emphasize chemistry as a discipline that asks relevant questions that chemistry allows us to address – e.g., how to identify pollutants in our drinking water, how to design a cold medicine, how to remove excess CO_2 from the atmosphere, whether cooking foods in certain plastics in a microwave is safe for children (Sevian & Talanquer, 2014). If students have opportunities to learn chemistry relevant to their lived worlds (Sevian & Bulte, 2015), more of the disenfranchised students gain traction and power in chemistry. I can't change my colleagues, but as a senior faculty in my department and at my university, I can create new avenues for these students to exercise their agency to employ their own chemical thinking, in ways that my colleagues can value as supports for struggling students. Maybe this is subversively possible beyond?

Corequisite mathematics remediation confers greater benefits to students than the traditional pre-requisite approach (Logue, Douglas, & Watanabe-Rose, 2019), so there is reason to expect this should hold for chemistry. I used activity theory (Engeström, 1999) to design a 1-credit supplemental general chemistry course, and then shepherded it through university governance. I will oversee the design and implementation for the first year as the curriculum is established, in exchange for fulfilling the university's wish that I study whether the course improves the DFW rate. A workshop version of the course is being piloted this fall, and the course will become a permanent offering starting in the spring, when one-third of general chemistry students will take it for credit alongside general chemistry. Students will place into supplemental chemistry if they score below 30th percentile in at least two components (general math ability, logical scientific reasoning, and prior chemistry knowledge) of the ACS diagnostic exam that is used for similar purpose at many universities in the US. The course's activity theory design adapts the principles of DeWitt and Osborne (2007): (1) adopt the perspective of the student, (2) provide structure that lowers the activation barrier for students to increase their agency, (3) encourage collaborative and social engagement in culturally and personally relevant activity, and (4) support dialogue, chemical literacy, and resourcefulness. I used conjecture mapping (Sandoval, 2014) to clarify design conjectures that link the embodiment of the course design to the mediating processes (based on best-practices research) and theoretical conjectures that connect the mediating processes to expected outcomes (drawn from research literature on relationships between student outcomes and particular processes). For example, a design conjecture is: Providing structured practice in the course (e.g., deliberate practice with order of operations and calculator use to solve problems) builds students' self-sufficiency in solving chemistry problems (a mediating process). An example of a theoretical conjecture is: Self-sufficiency in problem solving enhances positive feedback, augmenting students' agency in increasing their own repertoire of learning strategies (an intervention outcome) by building self-regulated learning strategies that lower the activation barrier to gaining more skills.

What messages go against the goals of succeeding in chemistry? What meanings do students attribute to their situations? How do students' connections with their communities (within and beyond chemistry class) change as they develop identity as people who can do chemistry? There are contradictions that lie within the answers to these questions, e.g., tensions between a student's home community and the classroom community. Activity theory experts helped me see that the contradictions will lend insight into understanding DFW-risk students' rich resources for succeeding in chemistry. To look for these contradictions, I need to build an initial sense of classes of contradictions that I expect to see: (1) subject (students) and object (success in chemistry) mediated by tools (e.g., models, homework, discourse): epistemology (how success in chemistry is known) vs. ontology (what success in chemistry is), (2) subject and community mediated by division of labor: tensions between individual and collective agency and identity, and (3) community and object mediated by rules: balances between the student as producer of learning vs. consumer of knowledge. Please help me build a plan to learn how to change the landscape for these amazing DFW-risk students at universities like mine.

Asli Sezen-Barrie, *University of Maine*

Vexation

> *If we were, if maybe we could – if that were the case, and we could have been grouped where at least one person would have been a special educator in every group to give us, kind of, to give, um, people like me who are general educators that, that assistance with well, how could we break this down? How could we, um, you know, uh, create activities that would, that would tar–, target all learners.* **(Mark, High School Science Teacher)**

This quote above is from a workshop where the teachers were working with tools such as explanatory models to scaffold students' construction of scientific knowledge. Although many teachers recognize the benefits of students' active participation in the knowledge construction process, most of the teachers repeatedly highlighted the challenge they face scaffolding students with special needs. This was the first step which took me on a path to start thinking more seriously about the access to STEM education for students with special needs. The need for teachers to learn about how to scaffold their students for scientific and engineering practices was more obvious when I moved to Maine and started working with teachers while they aligned their classroom activities and curriculum to NGSS (Next Generation Science Standards, 2013). Nationwide, students with disabilities represent 13% of all school aged children. in Maine, this percent is closer to 19%; 1 in every 5 students in Maine has an identified disability and receiving special education services (National Center for Educational Statistics, 2017b). The majority of these students are provided education in typical classrooms, including for science (National Center for Educational Statistics, 2017a; National Longitudinal Transition Study, n.d.). Additionally, the most recent National Assessment of Educational Progress science assessment suggests that slightly over a third of all fourth and eighth students and less than a quarter of all twelfth-grade students are meeting grade level indicators in science (Nations Report Card, 2015).

Given the number of students with disabilities in Maine, and other students who are not meeting grade-level science indicators, it is critical that science teachers have the tools necessary to support such learners. Science teachers who not equipped might disengage students with disabilities from science. This can be due to use of language and expressions which suggests to students with disabilities that they are not good at science. The *Next Generation Science Standards* (NGSS, 2013) focuses on implementing scientific practices (e.g., planning and carrying out investigations, arguing based on evidence) for all students including those who need special education services. Since enabling these practices in science classrooms means students' active engagement in constructing scientific knowledge (Windschitl & Stroupe, 2017), science teachers need the supports and tools to create or revise scientific activities that foster the active participations of students with and without disabilities.

I am interested in designing professional learning environments for science teachers to scaffold students with special needs for increased epistemic agency in science and engineering classrooms. Epistemic agency relates to the ways students participate in knowledge construction through practices in the context of their classroom (Stroupe, 2014; Damsa, Kirschner, Andriessen, Erkens, & Sins 2010). My studies so far have shown that the science teachers would limit opportunities for increased epistemic agency for students with special needs or teachers would lower the expectations of rigor in students' outcomes. Teachers' perceptions on who can have an increased epistemic agency raises a concern about equity goes against the idea highlighted in the *Framework* (2012) that *all* students should be meaningfully engaged in the scientific practices.

Venture

My route to venturing solutions to the problems of access to students with special needs has started with scholarly search engines. Soon after, I realized that the most research exists on isolated interventions for science. However, it is also imperative to explore teacher and larger curricular needs, such as the application of technology and Universal Design for Learning (see Therrien, Taylor, Hosp, Kaldenberg, & Gorsh, 2011, Watt, Therrien, Kaldenbeg, & Taylor, 2013). UDL is a framework that suggests improving instructional strategies to optimize learning for all students based on the research from how humans learn (King-Sears et al., 2015). Around the same time as I was buried into this literature, a colleague of mine from the Special Education program approached me with an interest to develop a project to increase engagement to STEM among students with special needs. This project will also help science teachers in Maine who are struggling to respond to the needs of students with special needs in their classrooms. To respond to the need to access students with special needs in Maine is timely because the state has just approved adoption of NGSS. Teachers around the state will now spend many professional development hours alignING their curriculum to NGSS. Some schools with more resources have been experimenting with some ideas or performance expectations of NGSS, but many remote rural schools have been using either old standards or Maine Learning Results.

Through my literature search and discussion with my colleagues in the special education department, I developed a list of strategies suggested for equitable classrooms which will improve scientific learning for students with or without special needs. These strategies include: 1) designing learning environments that remove obstacles for students with special needs, 2) utilizing technology to support students in communicative aspects of practices (i.e., writing, drawing, orally explaining), and 3) focusing on students' interests, background and creating relevancy. Another promising idea came from the recent publication of Alexis Patterson (2019) who looked at group work dynamics for opportunities to attend to inequities and work towards equitable interaction. She highlights social hierarchy through three dimensions: **a) student voic**e, **b) visibility** (of all students), and **c) student authority** — all important in designing a rigorous and responsive science learning environment beneficial for all students, and all diversities. This list provides me ideas for how I can work with other colleagues to promote inclusive, practice based science learning environments with a focus on improved student epistemic agency. However, I still find myself challenged with a question:

> ***How would these strategies help transform deeply rooted perceptions about students with specials needs in STEM learning environments?***

When I say perceptions here, I am not only referring to teachers' perceptions, but also other stakeholders such as school districts, principals, and parents. For example, some school districts decide to track students as honors, gifted, or lower track (academic, general, etc.). This separation then makes teachers change their practices for classrooms that are more suitable for students to be active agents in knowledge constructions. Another example can be parents who look for alternative outcomes for their kids who have special needs. These perceptions can limit use of the aforementioned strategies. Then within these constraints: "How can I design a statewide professional learning environment for science teachers to implement scientific and engineering practices in a way to increase epistemic agency for all students, including those with specials needs?" As I am new to this venture, I would love to get feedback from Science Education at the Crossroads colleagues to figure out best ways to design the professional learning environments for science teachers to create access to students with special needs.

The schools of Maine possess several advantages, with respect to accessibility. Maine has strived to provide low cost, high quality internet access to all schools, which enables the design of hybrid or online professional learning environments. Another advantage is the small class sizes (<21) that makes it easier to utilize individualized learning strategies. Moreover, there is an interest among the special education community to engage students into STEM education to increase academic involvement and success. Despite these advantages, some challenges remain. One such challenge that I have struggled with personally, is a dearth of research and program development centered on the intersection of special education and science education. This tends to lead to the over utilization of "hands-on" science or engineering activities, that are diluted conceptually. These activities are valued as "fun" but typically don't help students make sense of concepts or understand the complexity of scientific practices.

A Call for Accountability and Coalition

Manali J. Sheth, *Connecticut College*

Vexation "I look to my own experience and the experience of others like me to understand the world and to decide how to move it."

In her book of essays and speeches, "Where is your body?", Mari Matsuda (1997, xi), resisting the narrative that there are no radical Asian American women legal theorists, asks audiences to consider "how it is that where we stand shapes what we see, what we believe, and what privileges and subordinations we experience" as they work for transformation. Rooted in critical race and womyn of color feminist scholarship, my vexation is personal, as it gives voice to my experiences as a critical, U.S.-born Asian American womxn—somebody who is rendered nonexistent, invisible, inconsequential, and incapable of leadership in STEM education—and political, as it illuminates some of the systemic oppressions that Womyn of Colour experience across all levels of science education.

The arc of my k-20 education can be summed up in a quote a TA said to another Asian American students in one of my advanced undergraduate molecular biology courses: "You are Asian. You are going to be a doctor. You shouldn't be asking a question like that." Hoping to put my complaints about my education to use to do better for the next generation, I decided to become a science teacher. I was the only Womxn of Color in my teacher education courses and one of few people committed to working with Youth of Colour equitably, two issues with which the program did not engage. Upon getting certified, I successfully taught science in an urban school that served the most racially, ethnically, religiously, and linguistically diverse population in the city. However, I was burning out from doing much invisible and unsupported intellectual, emotional, and reflexive labor (Dillard, 2000) and the school was continuing to fail students of color in all the usual ways. White teachers, on the other hand, garnered material and psychosocial benefits that come from "helping those kids". Learning to "pivot the center" (Collins, 2002) so I could better learn from and teach students led me to graduate school with questions about equitable meaningful science education for Youth of Color who experienced injustices in every aspect of their lives.

During my doctoral education, as the only Womxn of Color in science education who had taught science with urban Youth of Colour, I was unshakeable in one thing: My research must be for and with students of color and address racism. This meant, at the risk of being seen as a troublemaker, non-intellectual, or not belonging, I was responsible for asking how our science education courses were relevant for urban students of color, my experiences as a teacher of color, and the inequitable contexts that shaped all of our lives. While there were many instances with colleagues, pre-service teachers, cooperating teachers, and faculty that made me wonder, "am I going crazy" (Gildersleeve, Croom, & Vasquez, 2011), two episodes stand out as letting me know my status in the academy. In science education, I was asked whether I found it troubling that nobody in the department knew anything about my interests while being told that my concerns about racism weren't science-specific—something that White people never had to think about because they had colorblind commitments. In multicultural education, I was asked who I was to do the work and why I didn't focus on my own people leaving other people to focus on theirs—something White people in the department were never asked because they were free to care about anything and everything. It was clear, I would need to lead my own program of study in science education, critical science studies, and multicultural education while cultivating my multiple consciousness or epistemological stance emerging from experiencing the world as an Asian American womxn subordinated by racism sexism who lives with the contradictions of how White and other people of color see her (Matsuda, 1989). In addition, engaging what I now know as feminist critical race praxis (Wing, 1997), I took leads on substantively changing aspects of the science teacher education program and developing an Indigenous community-based culturally relevant science curriculum. Although I intellectually and materially led much of the work, I was eventually put back in my place for saying "no" to unjust power relations reminding me that the role of Asian Americans was to quietly work for the benefits of White people with no claims to what we needed for life or justice (Takaki, 1989).

Upon earning my PhD, I began a lecturer position science education at Iowa State. My doctoral credentials should have conferred me expertise in science teacher education, specifically ambitious science teaching, equitable science education, and modeling based inquiry. Instead, I was positioned as a teaching assistant who could observe or join a student group while the science teacher education courses pushed a curriculum of technical science teaching, powerblind nature of science, and racist ideologies suggesting that multicultural education was bad for American society and science learning. Not one to stay quiet, I asserted counter-stories (Solórzano & Yosso, 2002) from the back of the classroom. When asked by an administrator—who was holding my CV—whether I could have taught the courses from the beginning, I answered in disbelief that I had been doing science teacher education for six years at one of the top programs in the country. Eventually, I was offered a tenure-track line with the condition that it could not be science education. Doing what WoC do when forced to swerve (Obama, 2018), I aligned myself with and became the area lead for the Social and Cultural Studies of Education. In this role, I took on re-designing the critical social justice education course for the MAT science, mathematics, and agricultural education pre-service teachers. One of the goals of the course was to engage in critical analyses of disciplinary knowledge production practices and powerblind teaching and learning frameworks. Knowing the silences, anger, and dismissals of credentials that I would be up against (Evans-Winters & Twyman Hoff, 2011), I prepared for every class session ready to deftly draw upon critical race and feminist pedagogies, ambitious teaching practices, critical theories, historical evidence, critical science studies, and an assortment of experiences to break down the MAT students' verbal gymnastics (Bonilla-Silva, 2013), willful ignorance (Mills, 2007), and years of miseducation in the sciences. While this was going on in the classroom, the institution and senior white colleagues and colleagues of color continued to reify the deeply entrenched Black-White binary (Alcoff, 2003) and the invisibility of Asian Americans, which as Yamada (1979) states is an unnatural disaster. Writing took a backseat to surviving and my focus shifted to critically examining the learning experiences of Womyn Non-Binary People of Colour (WNBPoC) and youth voice initiatives. I resigned my position at ISU in December 2017 when it became unequivocally clear that I, like so many critical scholars of color who had been recruited but not retained, was completely shut out of pursuing any meaningful work at the institution.

Venture

> "Freeing yourself was one thing, claiming ownership over that freed self was another."
> *Toni Morrison, Beloved, 1987, p. 112*

It wasn't science that instilled in me a sense of wonder or justice, it was the experiences of those close to me and authors like Toni Morrison. I am at a crossroads in my career with the freedom to decide how I want to focus my time, energy, and efforts. My new academic home is a small liberal arts college whose education department is rooted in justice-oriented education and critical pedagogies. The institution values teaching and quality research. It does not have a stand-alone science teacher education program or a doctoral program. I have a newly found optimism. However, my frustrations with the oppressive nature of science education as a field and the field's lack of accountability, critical reflexivity, justice-oriented perspectives, and coalition-building regularly make me feel that the venture of being a feminist critical race Asian American woman scholar activist in science education is impossible. But as Derrick Bell (1992) reminds us, "just because it is impossible doesn't mean we don't try" so I am going to try to envision the political project that I want to drive/anchor my science education research. Part of my venture is to attend this conference and figure out what, if any, relationship I want with the field of science education. I am aware that my Asian American womxn's body needs to do the work of rendering my experiences legible while working in solidarity with other subordinated groups who are positioned differently in the field. This means choosing to sometimes work from the margins (hooks, 1989) of science education, sometimes as an outsider within (Collins, 1986), and sometimes as a bridge (Anzaldúa & Moraga, 1984).

Part of my venture is writing the Vexation as a preliminary theorizing of my experiences to develop into a manuscript that argues for bringing to light the ways in which science education, as a field, oppressively pushes out the people and perspectives that can offer transformative leadership and offers more expansive conceptualizations of equity and justice in the field. For example, if Asian Americans and international Asians were historically positioned as morally decrepit perils and have currently been re-positioned as the solution (Prashad, 2000) in science—robotic and apolitical, then how can we work towards racial justice for Black and Latinx communities without examining how science racializes Asian Americans and reconsidering what Asian Americans are learning to become within their science educations? What are the epistemic experiences/practices of WNBPoC and how do current renderings of doing science obscure/marginalize those experiences/practices? How can we lead towards equitable science education from an understanding of social activism and coalition-building from feminist critical race frameworks that ask us to negotiate political interests across differences in ways that address intersecting oppressions experienced at relational and structural levels—that ask us to stand next to each other facing the enemy embedded within ourselves and our institutions?

From the incubator session I hope to gain insights that can help me 1) figure out how to reacclimate to the field of science education, develop a writing practice to finish all the half-written manuscripts that have been deferred for the past four years, and engage with new praxis projects, 2) identify concrete navigational steps to connect with like-minded people in the field in non-exploitative professional relationships and/or 3) identify next steps in building the Vexation out into a manuscript.

Navigating Complicated Terrain: STEM, STEAM, & Equity

Teresa Shume, *North Dakota State University*

Vexation

In recent years, there have been calls to rethink STEM education to make room for more humanistic approaches that embrace social, cultural, and moral contexts of science education (e.g. Zeidler, 2014; Kahn & Zeidler, 2016). Movements to expand STEM to STEAM by adding the arts have flourished. For example, Yak's (2008) STEAM framework stands for "Science and Technology interpreted through Engineering and the Arts, all based in Mathematical elements" and utilizes a socio-cultural, interdisciplinary, holistic approach. Similarly, STEAM by Design (Keane & Keane, 2016) deploys place-based projects to develop "social, cultural, technological, environmental, and economic responses to existing and future conditions" that position students as "citizen activists in the communities in which they live and learn" (p. 61). Efforts to reframe STEM into STEAM often seek to empower student voices through project-based learning, capitalize on the role of creativity in the design process, make room for social justice, support democracy, and strive to remove barriers in order to more fully integrate subject areas. STEAM education anchored in transdisciplinary project-based learning that deeply integrates learning experiences across multiple subject areas resonates with inclusive "for-all" orientations that stand in contrast to traditional "pipeline" orientations to STEM education focused squarely on preparing the next generation of STEM professionals.

The movement toward STEAM education has given rise to approaches that integrate additional disciplines beyond Art. Orange County Public Schools in Florida developed a model called STREAMS that adds Reading, Arts, and Social Studies to STEM (Vasquez, Sneider, & Comer, 2013). Other words used for various acronyms to expand STEM include: innovation, entrepreneurship, (Weidemann, 2018), robotics, multimedia, medicine (Fuller, 2018) as well as law, economics, and logic (Ferrari, 2018). Given the proliferation of acronym variants, I sympathize with Meagan Pollock who laments tongue in cheek, "Is it STEM or STEAM? Why not STREAM? This battle of acronyms makes me want to SCREAM!" (Pollock, 2012). Nonetheless, many approaches to STEAM and its variants challenge the neoliberal hegemony that drives STEM's traditionally narrow focus on workforce demands, job readiness, and economic competitiveness in a globalized world marketplace.

The heart of my vexation has two prongs. First, I wonder if the multitude of conceptions of STEM and its variants has resulted in STEM becoming so impossibly vast that it encompasses everything and means nothing. Has STEM education become so multifarious that it has lost any meaningful boundaries or possibility to possess a core essence? Do fundamental constructs, such the nature of the engineering design process applied to the development of technologies to meet human needs and wants, hold a place of value in the scope of today's STEM education? Or have such core constructs been overwhelmed and dissolved by alternate aims advanced by STEAM and other variants of STEM? What is lost when STEM becomes STEAM and beyond?

Second, and somewhat conversely, I wonder if STEAM education inadvertently strengthens the neoliberal hegemony that underpins traditional STEM education. Does "STEAM for all" disrupt "STEM pipeline" thinking or tacitly affirm it by drawing on the socio-political power traditionally accorded to STEM fields? Does the labeling of transdisciplinary project-based learning approaches as STEAM unnecessarily pay homage to STEM when such initiatives could stand on their own merits without affiliation with STEM or STEAM? Does the use of the STEAM label result in inclusive, transdisciplinary, "for-all" initiatives becoming reduced to just another means to the ultimate end of expanding the pool of potential STEM pipeline candidates? Why are transdisciplinary project-based learning approaches that aim to empower citizen activists attached to STEM at all?

Venture

Three years ago, I found myself stepping into the role of instructor for an established professional development program that places K-12 educators in industry internships for four weeks during the summer, and involves a 2-credit continuing education course in the summer and a 1-credit continuing education course in the fall. The internship experiences provide a firsthand look at how the engineering design process and 21st century skills are applied in industry environments such as engineering firms, manufacturing companies, and other corporate workplaces. Rather than being assigned to a single department within the company, participants are intentionally scheduled to move around to various departments within the company during their four-week experience… to gain an overall understanding of how the company operates, and to equip teachers with increased awareness and knowledge about the engineering design process, 21st century skills, and career opportunities in STEM fields.

Navigating Complicated Terrain: STEM, STEAM, & Equity

Teresa Shume, *North Dakota State University*

This year, for the first time since I "inherited" this program, participating educators included two teachers from a local school where the conception of STEM education is essentially synonymous with transdisciplinary project-based learning that encompasses several subject areas and does not privilege the four STEM subject areas over other subject areas. At this school, the bell schedule and teachers' planning times are configured to support the design and implementation of transdisciplinary project-based learning. The school's STEM coordinator once proudly shared with me a story about how some students used "the engineering design process" to write and refine proposed legislation as their solution to an environmental pollution problem prevalent in the state. I also recall a time when the district's Curriculum Director explained how she worked with a student who had come to use "the engineering design process" so frequently in her daily life that she even used in the morning when deciding what to wear. Broadly conceiving of engineering design as any problem-solving process that includes iterative cycles of refinement is ensconced in the district's vision and planning documents. Further, two articles published in practitioner-oriented journals by educators from this school frame STEM education as a transdisciplinary approach that integrates a full complement of subject areas. These articles also draw on a wide-open conception of the engineering design process that equates with iterative problem-solving process. Notably, this district has consistently used the term "STEM" rather than STEAM or any other STEM variation.

At the start of this year's program, I anticipated that the two participating teachers from this particular school were likely to begin their internship placements with conceptions of STEM education that resonated with the perspectives and practices implemented within their building and district. I was torn about how to approach this delicate issue during the 2019 program. On one hand, I wanted to challenge this overly-encompassing conception of engineering design process being implemented within an overly-encompassing conception of STEM education, yet I also want to honor the work, commitment, and success of this school and district in implementing an inclusive "for-all" transdisciplinary project based learning approach. An impressive array of student-driven projects based on authentic curricular integration and meaningful community connections have been produced to date.

As the summer unfolded, I came to understand each of these two teachers' own ideas about engineering design process and STEM education. Their internship experiences did impact their beliefs, but not always in ways I had anticipated. Through class discussions and written reflections, a rich exchange of ideas took place among all the teachers participating in the program this summer. A theme we visited a number of times was equity, particularly with regards to ways that STEM education in their schools might respond to disparities in socio-economic status among students. Now that the participating teachers are returning to their schools as the new academic year begins, they may find themselves grappling with some problematic incongruences, yet hopefully will also find themselves better positioned to contextualize their ideas and beliefs within a broader scope because of their summer internship and learning experiences. As the fall progresses, it will be interesting to see if opportunities arise to lead efforts that challenge ensconced perspectives on STEM education along with associated policies and practices within their school buildings and possibly at the broader district level.

I hope to engage the Crossroads community to discuss the following questions:

A. What are some ideas (e.g. instructional strategies, program components, etc.) I can use to help teacher-learners to move beyond responses to inequity focused on increasing access to the STEM pipeline as it currently exists, and to explore ones that **transform/disrupt pipeline thinking**?

B. As a university faculty member, **how can I support teachers to provide school leadership** with regards to sharing insights gained/affirmed through reflecting on their industry internship experience, particularly when some insights may run contrary to broadly held school/district beliefs about STEM concepts (e.g. engineering design process) and STEM pipeline thinking?

C. What are **potential consequences** (intended or not) of applying labels such as STEM, STEAM, etc. to transdisciplinary project-based learning that empowers students as citizen activists?

The Need to Go Beyond the Equity Buzzwords: How can we Institutionalize Doing Right by the *Other*?

Sherry A. Southerland, *Florida State University*

Vexation

> *achievement gaps … opportunity gaps … microaggressions … micro messages … underrepresented minorities … minoritized learners … sociopolitical consciousness … chilly climates … high expectations … community partners … funds of knowledge … cognitive resources …*

Each of these terms and a host of others have emerged as science educators have become aware of the need, and/or accepted the charge, to better attend to all the learners in our classrooms. Even as I write this, I find myself slipping back into the language of "Science for All Americans" (AAAS, 1989), with its call for science educators to support *ALL Americans* in becoming scientifically literate. That lovely, compelling document, however moving, was vague as to how teachers could best support "all" students in developing literacy in science. Thankfully, in the ensuing 30 or so years, the field has developed more clarity in terms of the real challenges embedded in this call as well as identifying some pathways necessary to move forward in meeting those challenges.

I'm pleased to see that as a research community, science educators are far more aware of equity considerations in our work, especially the particular needs of students of color, English language learners and children in poverty. While the work of striving toward a more equitable science education remains, the acknowledgement of the need for such effort is now an established norm in our research communities. In funding review panels, a common question is "What does [fill in the activity] mean for underrepresented populations"? Strands at conferences are devoted to "equity" concerns. Journals commonly attend to the need to diversify their editorial boards, in the hope that diverse views and commitments will ensure that the knowledge produced attends to the learning needs of *all* science learners.

Given the established attention equity receives in our organizational and epistemic structures, we expect novice science educators (from teachers to doctoral students) to be capable of taking the fruits of our efforts and apply them in ways to better support the learning of underrepresented learners — either through a specific teaching move or research design. As a science educator — teacher and mentor — I am quite comfortable challenging my students' views of their role in teaching — and their abilities to teach — *all* students science. However, a recent event challenged the comfortable boundaries I have established for myself in working toward equity. I work at Florida State University, a large, southern, research intensive university located in a relatively conservative town. For a variety of reasons, our undergraduate student population is largely composed of white, middle-class, high achieving students. In contrast, at the graduate level, we've been successful in diversifying our ranks in recent years, including more students and faculty from diverse backgrounds (including scholars of color and international scholars), even though the larger university remains a largely white institution. Recently, a student of mine, a scholar of color, suggested to me that while science educators know a lot about equity at a distance, we often fail to take that same knowledge and apply it to understanding and shaping our own actions in our local community. As an example, she described a classroom episode in which our group of emerging scholars of science education carefully read and considered a manuscript devoted to culturally responsive pedagogy in science — all the while unknowingly sitting a racially segregated tables. Or, in our heated conversations about the inclusion of socio-political concerns in the science classrooms, students from the majority group unknowingly talk over others from a racial minority.

When these occurrences were first brought to my attention, I was quick to be defensive of the group. Certainly, I mused, these events are to be expected as days in graduate classes grow long and folks become short of sleep. Of course, I continued, these are small blunders that are to be expected in a close-knit group as we all struggle to meet varied and sometimes competing demands. Or maybe what we are seeing is simply the result of clashing discursive norms, with those students more recently from the hard sciences enacting their "science identities" in our discussions?

At the time, my immediate response to my student's concern was "It's my job as a graduate mentor to teach students to work for equity in schools—either through teaching or research, but it's not my role to shape their interpersonal reactions with one another." To myself, I mused, "One has to have boundaries, after all." After my student left, I continued my self dialogue, "I didn't bring these students together to become some sort of social justice warriors. They came here to become capable science educators. Right?" I was uncomfortable with this answer even as I said this to myself. In the weeks afterwards, I considered my work with preservice teachers with this nagging problem in mind. Yes, in methods courses we discuss opportunity gaps and the roles teacher expectations play in shaping the kinds of quality of science experiences students are allowed to engage in. But, these same undergraduate students sometimes roll their eyes as we wait for a particularly slow student to voice her opinions or they may "jump" quickly to strongly critique and dismiss ideas offered by their more conservative counterparts. In our methods courses we focus on techniques to allow teacher candidates to listen carefully to all students in the K-12 settings, but do we do enough to ensure that they extend the same courtesy to each other? Is that my even my role?

My vexation revolves around identifying my role as a mentor of novice teachers and novice teacher educator in moving beyond the teaching about the application of equitable teaching and research practices at a distance, and ensuring that ***we are treating one another, or colleagues, in equitable ways***. My vexation is grappling with the question "How can we institutionalize "doing right" by the other in our own classrooms AS we also teach our students the knowledge and skills necessary for them to be useful assets in K-12 classrooms?" I must admit a fear that I have, that the dual attention will be distracting. That is, I'm concerned the work we take to be more locally equitable will detract from our efforts to better support our diverse array of learners a at distance. Part of me recognizes that this simply reflects my fear of the unknown — I don't know how to attend to such simultaneous demands. Thus, the prospect of including even additional considerations — particularly likely uncomfortable conversations as we grapple with expressions of bias, privileged, and challenge social norms — is frightening. I lack expertise in navigating these issues and participating in such conversations. Worse yet, I shy away from conflict and I take no pleasure in making people uncomfortable. Too, I imagine that there are institutional barriers that make such work difficult of which I am presently unaware. Thus, the venture for me evokes some trepidation.

Venture

To address this vexation, I propose the following multistep venture. We have a number of social justice-oriented workshops on campus, some focused on becoming a social justice ally and a diversity and inclusion certificate series for faculty and staff offered through the Center for Leadership and Social Change. I intend to participate in these activities and employ the techniques and commitments learned there in my own STEM courses, in my mentoring efforts with the doctoral students in science education, and in my own work as a departmental chair. I have a number of new colleagues knowledgeable about and committed to social justice practices, and I will ask one of them to serve as a mentor for me in this regard to provide for me needed guidance as I work to change my practices. Following this, I will invite my colleagues in teacher preparation, in science education, and in the department at large to engage in similar activities so that we can begin to understand our work through the lens of social justice.

Other activities I am considering include establishing an interdisciplinary reading/working group that focuses specifically on issues related to equity and social justice in university settings as its primary focus. Perhaps we could invite speakers whose work centers equity in the university setting. In the past, I would have considered this expenditure of resources on "self-care" — that is the maintenance of the communities of university educators — to be self-involved or myopic. Now as we work to diversify this community, I am coming to realize that we need to develop the skill-set and sensibilities to ensure that our diverse local communities are equitable. I've been told that this kind of work does require explicit, sustained attention and I'm anxious to find a way to achieve this dual focus in my work so that we work toward equity in our own learning communities as we work to support equity for science learners in schools.

A Tale of Two Leadership Networks: Centering & Sustaining Equity

Jessica Thompson, *University of Washington*

Vexation

Over the past 7 years our research team has been involved in two research-practice partnership projects, both of which developed teacher leaders that support the advancement of ambitious and equitable science teaching. The first is a single-district networked improvement community (NIC, Bryk, et al., 2011) that grew teacher leaders over four years, and involved all secondary science teachers in the district (N=50 teachers/year, 96 teachers over four years including turnover, Figure 1A). The second is a multi-district NIC spanning Western Washington that began with 42 teachers identified by their districts as potential leaders, then grew to include 184 teachers over three years (Figure 1B). Both used a distributed approach to leadership; going beyond "naming leaders" to empowering social activity among actors (Spillane et al., 2003) and investing in the development and iteration of tools (Hargreaves & Fullan, 2012).

Equity in these networks was conceptualized in two ways. First, both networks aimed to expand membership as a form of equity of inclusion. We took a systems approach and invested in as many teachers as possible, avoiding the trap of only partnering with early-adopters or "superstar" teachers. We wanted maximum involvement of teachers and K-12 students. In the single-district network, we started with two schools then grew to 9, bringing on all members of the secondary science departments (plus teachers from 5 elementary schools). Participation was optional but all teachers opted to participate in part because the teachers were supported in working with school-based PLCs and they had autonomy in determining their specific school aim. All teams worked with Ambitious Science Teaching practices and a broad network aim to improve practices and tools supporting scientific explanations, models and argumentation for all students, but specifically for Emergent Bilingual (EB) students. In the multidistrict network 42 teachers were selected by districts as potential teacher leaders. The first year, teachers focused on improving their own curriculum and instructional teaching practices drawing on the AST practices, and in the second year they were asked to "bring a buddy." Some teachers brought one critical friend from their school and others brought 20 teachers from across their district. Teacher leaders and teachers worked on improving opportunities for student sense-making.

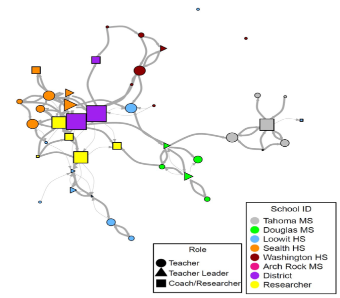


Figure 1A. Single-district NIC (year 4)

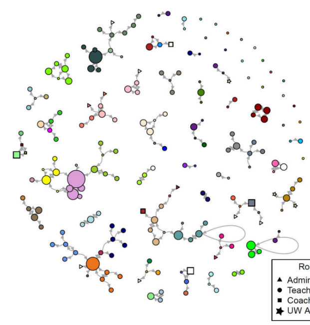


Figure 1B. Multi-district NIC (year 2)

Second, each project worked on "equity-in-practice," meaning the networks worked on the development of instructional practices that valued, built on and were responsive to students' funds of knowledge, lived experiences. While the multi-district project focused on sense-making for all students, the single-district NIC attempted to focus on EBs in particular. Over four years the network began to shift how they interacted to support EBs (as seen in Figure 1A), which shows ties among teacher leaders, teachers, coaches and researchers in which participants reported specifically focusing on the improvement of teaching with EBs (this kind of interaction improved twofold compared to all other forms of interactions). While the networks attempted to shift classroom interactions away from pedagogies of oppression on the whole, the transformational work on issues of social justice and restorative justice remained in pockets. For example, teaches in the multi-district NIC development of an interdisciplinary unit on HELA cells that examined bioethics and race that spread to several classrooms. The single-district developed two science teaching practices that merged EB instructional techniques with AST, supporting students in language development, the use of home languages in science, and engaging students in conversations about metalinguistics and language functions.

Thus, while the networks were infastructured (Penuel, 2019) around leadership and equity differently, and they both ended up being sustained beyond the life of grant funding, they both tell the same tale: in designing for ambitious and equitable science teaching, networks can still "pull up short" (Kerdeman, 2003). More is needed to fundamentally transform opportunities for culturally and linguistically diverse K-12 students. Which leaves me to question, how do you structure networks to work on transformational equity-in-practice? Is this even possible with improvement networks?

Venture

We are launching a third network with 1200 elementary teachers in Seattle Public Schools. Two summers ago, we started working with 30 teacher leaders; we adapted a few AST units for multilingual settings, partnered with a community center to teach the units, then supported 400 K-5 SPS teachers to teach and reflect on the same units. This fall as SPS works with newly adopted curriculum we plan to launch a community effort around equity, integrated with AST practices. Below, we propose three modified AST instructional foci (one for each year) that have the potential to support equity in classrooms and that can be the object of study and improvement for each subsequent year of the project. My questions for Crossroads folks are: ***Are these the right foci? Are they transformational, or necessary starting places? How do we engage in critical conversations around race and language within each foci? What are techniques for doing this deep equity work at scale?***

Year 1. <u>Noticing students' cultural resources and experiences</u> and using these to plan and adapt culturally relevant, place-based phenomena that are meaningful to children's lives. The AST practices begin with scientific modeling and inviting students to reason about and construct explanations of puzzling phenomena in the natural world (Windschitl, Thompson, & Braaten, 2018). Teachers use puzzling phenomena from the curriculum or they select their own phenomenon that they believe are relevant to students, such that science can be made accessible for students and encourage them to start from what they know. This process approximates relevance. We plan to support PLCs in inquiring into strategies and tools that can help them learn about their students' and students' families' connections to the content and to ways of doing science, and invite teachers to make modifications to the unit and to the model scaffold for the unit. PLCs will plan for and investigate how tools such as the model scaffold afford or constrain opportunities for students to build on their funds of knowledge, and can refine practical measures that give them feedback from students (and potentially families). This way, we can honor students' emerging ideas and capabilities in the knowledge building processes of modeling (Lehrer & Schauble, 2006). We will also focus on expansive methods for noticing students' capabilities and diverse ways of communicating their ideas (gesturing, translanguaging) and explicitly work on developing asset-based perspectives about diverse students (Hand, Penuel, Gutiérrez, 2012; Suárez, 2018).

Year 2. <u>Positioning students as active knowledge builders</u>, encouraging students' collaboration and learning from one another in constructing models, explanations and arguments & supporting linguistically diverse students in classroom discourse. The AST practices support students in making sense of activities, revising models and constructing evidence-based explanations and arguments, but do not explicitly support students in drawing on their linguistic resources. In SPS there are bilingual programs where students take science in a different language (Spanish, Mandarin, Japanese) and in many classrooms at least 20% of the students are EBs. We want to support PLCs in developing discourse protocols and tools that build on students' linguistic resources. We reason that when teachers teach the language of scientific ways of thinking and then provide structured ways to practice using academic language, students can take an active role in building knowledge for themselves and their classroom communities (Schleppegrell, 2013; Lee & Buxton, 2013). Furthermore, when students are positioned in this way they define what counts as productive epistemic discourses among students (Louca, Zacharia, & Constantinou, 2011; Williams & Clement, 2015), and build epistemic norms and cultures in classrooms (Berland et al., 2016). We will encourage PLCs to design and engage in cycles of inquiry with instructional strategies and tools to support linguistically diverse students—e.g., structuring talk opportunities, encouraging the use of home languages—and support PLCs in attending to how and what students learn in the process.

Year 3. <u>Soliciting feedback from students about their learning and their experiences</u>. More than formatively assessing constructs learned we will ask students to describe how and why they participated/ or not. To support students' meaningful participation in scientific practices, it is important to attend to how students understand the goals and meanings of the practices that they engage in (Berland et al., 2016). While we plan to provide exit tickets each year, in year 3 we will engage PLCs in developing and iterating on exit tickets as they seek to build productive epistemic cultures together with students. PLCs can investigate how culturally and linguistically diverse students experience their classrooms and continue to refine planning and discourse tools (from years 1 and 2) based on this data.

Bhaskar Upadhyay, *University of Minnesota*

Vexation

In the last two years, I have been struggling to figure out how to rethink indigenous participation in science education. Most of the works that have been published have come out of the Western notions of who counts as indigenous, how indigenous knowledge and ways of being should look like, and how indigenous data should be collected and interpreted. Some scholars in science education and beyond have argued for greater focus on indigenous epistemologies but others have argued for decolonizing framework and some others have argued for indigenous perspectives on the nature of science knowledge and ways of being researched (e.g., Debassige & Brunette-Debassige, 2018; Pugh, McGinty, & Bang, 2019; Smith, 1999). In all of these works and my own work with indigenous Tharu people of Nepal has followed the Western notions of indigenous and interpretations. Even though the Western ways of understanding indigenous people has given me tools to give labels to my works with indigenous people and communities in Nepal, I have found these tools and frameworks lacking or challenging in many ways. Thus my vexation is attempting to further collaborate with indigenous people, language, culture, food, and their communities for sociopolitical change and transformation. In all my vexations, race is central to thinking about equity and social change in science education or STEM education for that matter.

The first big question that has vexed me is the idea of indigenous. Nepali language uses the word "aadi-baasi" [***aadi-*** beginning of time; ***baasi*** inhabitant/resident] to indicate an indigenous group. The word means "people who have been living since the beginning of time" at a place but the English word "indigenous" doesn't capture this very unique meaning to talk about and understand indigenous people. Nepali word values "time" as the foundational aspect of being indigenous but the English word values "place" the key aspect of being indigenous. So how would one rethink indigenous in the context of Nepal or for that matter any other place that sees indigenous differently from the Western view.

Second in the context of Nepal, the educational system is now becoming more decentralized. Local communities, including indigenous communities, are engaging in reshaping education based on the needs and desires of the community. Local control in education needs visionary leaders from indigenous communities who can shape schools, curriculum, pedagogies, and teachers based on their values and beliefs. Yet many indigenous communities get left behind in these reform efforts because they don't have leaders from their communities who know the education system well. So how does one go about building leadership and human capacity within the indigenous community? What resources would be essential to prepare indigenous adults to be leaders for educational reform for social change?

Third is the contested idea of indigenization (Gaudry & Lorenz, 2018). What does indigenization mean in the context of system level change such as the ability of indigenous communities to create their own curriculum in all content areas and set their own content and assessment standards. What does indigenizing science education mean; how does that influence what science is learned and what skills are developed?

I want to draw attention of the readers to the idea of "appropriation". I am acutely aware of how not to fall in this trap. For many marginalized groups appropriation of their knowledge, artifacts, cultural practices, and their contributions by more powerful researchers, institutions, and organizations has become a normal part of their being. Powerful institutions have regularly "appropriated" indigenous communities and, thus, aided in their marginalization. When I looked at how Chris Emdin (2016) drew parallels between indigenous students' struggles to learn science with inner-city students and coined the term "neoindigenoues", I felt discomfort in this labeling. I admire Emdin's efforts in highlighting the struggles and marginalization of inner-city youths and attempting to give (propose) solutions but I struggled to not find his use of "neoindigenous" as another "appropriation" of "indigenous" community's history, culture, practices, and suffrage. Therefore I wonder whether "drawing parallels between my own efforts and your own efforts in inner-city schools and youth, rural schools, populations with unique cultures and abilities, etc. could be useful and if it is then what could they be and also the limits of the actions in these diverse contexts." Finally, in order to support science educators in this kind of work, what could be some of the resources and opportunities required to encourage them to act?

Venture

My journey in science education has revolved around how greater number of marginalized groups could have access to science education and how science education could be for greater social change and democracy. This journey has helped me better understand and appreciate how marginalized schools, people, communities, language, culture, etc. are pushed aside in the larger dominant science education systems. Therefore creating a systemically less democratic and more oppressive science education where dominant narrative of science eradicates the local ways of knowing, being, and living. In any learning voices of the learner and their communities are essential for a learning to be lasting and personal. Yet marginalized voices get removed from the highest level of education system to the lowest levels, the classrooms. This silencing has made science education more distant from those groups that need the most support to reap the future benefits of science learning.

Additionally I have also found that when marginalized voices are supported, encouraged, and valued science education has allowed learners to seek for sociopolitical change in their own schools and communities, take environmental actions, work for sustainable local actions, and help indigenize science for better future. I must acknowledge that in this journey I'm being helped by theoretical and philosophical frameworks of scholars that have viewed education and education systems through anti-oppressive, anti-racist and decolonizing lenses (e.g., Freire, 1984; Giroux, 1998; Kincheloe, 2008; Ladson-Billings, 1995; Martín-Baró, 1996; McLaren, Rawls, 1999; Smith, 1999). These theories have pushed me to think about and consider science education, and specifically science teaching, from a moral perspective too. Anti-oppressive, anti-racist, and decolonizing ideas are based on the premise that it is "immoral" to marginalize people who don't look like the "majority or the one in power." Furthermore, in the context of current "STEM" movement, science education has to further rethink equity issues from a moral stance — who gets to participate and who gets left behind. Most K-12 schools find "STEM" as a way to make science learning experience authentic by focusing on "problem-based" teaching and learning but generally failing to engage students in moral dilemmas of "problem-based" solutions or learning. Without moral engagement, the focus on "STEM" education at the K-12 level is not helping students to see science learning for social change and transformation. Therefore exploring "STEM" or "STEAM" teaching and learning from anti-oppressive, anti-racist, and decolonizing perspectives is essential if we believe that science education sociopolitical change and transformation.

Racial and Ethnic Representation in High School STEM: Towards a Framework that Informs School Leader Decisions about High Quality and Successful STEM Teaching and Learning Practices

Noemi Waight, *University of Buffalo*

Vexation

Research on the outcomes of reform efforts in science education often focus on the role of teachers and students and associated classroom dynamics (National Research Council, 2011). However, research on the role of school leadership reveal significant limitations with this perspective. The Wallace Foundation (2013) reported that most [educational] variables, considered separately, have at most small effects on learning" (p.4). In converse, they argued that educational yield is maximized when understandings of more variables are combined to inform better models, and in this case, models of science education reform. Indeed, Wahlstrom, Louis, Leithwood, and Anderson (2010) reported that it has been well established that school leadership follows teacher quality and classroom instruction as the next most important variable. Most recently, Lochmiller and Acker-Hocevar (2016) affirmed that principals can improve math and science achievement by promoting conditions favorable to teacher collaboration and innovative instruction. Still yet, Lochmiller and Acker-Hocevar acknowledged a notable paucity of research on principals' "instructional leadership" in math and science. In response, they suggested the need to examine the ways in which principals make sense of the need to provide support and improve instruction in science: "more research is needed to understand how principals determine what leadership actions to take, as well as why they should be taken" (p. 274).

The purpose of this vexation is to examine the nature of school leadership in a STEM-inclusive secondary school that primarily serves students from racial, cultural and linguistically diverse backgrounds. More specifically, what knowledge informs how school leaders make decisions that prepare urban students to be successful in science education. What culturally sustaining knowledge and practices is necessary in order to ensure that optimal science teaching and learning is facilitated? What resources, support, and associated professional development are essential for science teachers in this context? In what ways do school leaders' decisions inform students' performance and affirming experiences in science education?

The role of school leadership and STEM success at the secondary level is significant in light of Maltese and Tai's (2011) claims that the majority of students who chose STEM fields, did so at the high school level and specifically, these choices were based on growing interest in Math and Science and not necessarily enrollment or achievement. The attention here is warranted because the bulk of studies related to persistence and representation in STEM of ethnic and racial minoritized students occurs at the college level (Museus, Palmer, Davis & Maramba, 2011). This suggests that more studies in the context of high school preparedness for racial and linguistically diverse minoritized students should be conducted in the context of high school science, math, and engineering. According to the Museus et al., students' interest in STEM in high needs environments are often stagnated due to school district funding differences; tracking into remedial courses; lack of opportunities for advanced placement courses; lack of qualified teachers, low teacher expectations; stereotype threat; oppositional culture; and high attrition rates (ASHE report, p. 29). These conditions which limit opportunities for quality STEM experiences at the high school level reinforce the urgency to examine how school leadership inform models of STEM classroom practice.

The above questions are also posed in light of the current shift that marks the adoption and implementation of the Next Generation Science Standards (NGSS) [NGSS Lead States, 2013], designed to engage students at the intersection of three dimensions: science and engineering practices, cross cutting concepts, and disciplinary core ideas (Lead States, 2013). The realization of NGSS is linked to authentic classroom practices such as technology-supported, inquiry-based approaches (Waight & Abd-El-Khalick, 2012).

The Wallace Foundation (2013, p. 6) documented that school success is informed by school leaders who engage in continuous learning and who cultivate a team delivering effective instruction. In this regard, five key responsibilities were outlined: "Shaping a vision of academic success for all students, one based on high standards, creating a climate hospitable to education in order to ensure safety; a cooperative spirit and other foundations of fruitful interaction; cultivating leadership in others so that teachers and other adults assume their parts in realizing the school vision; improving instruction to enable teachers to teach at their best and students to learn to their utmost; managing people, data and processes to foster school improvement." What is absent from these studies is an understanding of how school success is related to STEM and more specifically science education success. Even more specific, there are limited studies about the role of school leadership related to the success of students in STEM from cultural, racial and linguistically diverse backgrounds in urban high schools.

Venture

The subtext of school leadership is that instructional leadership roles are often more effectively enacted at the elementary versus middle and high school level. The report notes that the major challenges at these levels are lack of understanding related to multifaceted discipline-specific focus at the high school level. While department heads are viewed as bridging agents who co-facilitate and negotiate leadership roles, the bulk of the studies emphasize that school leaders remain significant in overall school success. In fact, Leithwood, Patten and Jantzi (2010) noted that school leaders exert significant effects on the improvement of student learning and these effects are context-dependent. The authors conceptualized four distinct paths along which leadership flows to improve student learning. They identified the Rational, Emotions, Organizational, and Family path. The rational path focused on the knowledge and skills about staff and curriculum, teaching and learning. This includes both classroom and school level variables. The emotions path focused on feelings, dispositions, or the affective states of staff members both individually or collectively about school related matters. For the organizational path, the focus was on "features of schools that frame the relationships and interactions among organizational members including for example, structures, cultures, policies, and standard operating procedures" (p. 678). From the school perspective, family factors account for unalterable and alterable factors. As noted, unalterable factors are those for which the school has no influence. In contrast, alterable factors can be influenced by the school and its leadership and this includes focus on family educational culture. These pathways target overall improvement as opposed to specific science (or math) improvement. I posit that more STEM-centric pathways will need to be identified in order to understand how and why school leaders' decision making impact improved science learning.

Given the above, this venture aims to understand how the above practices translate to students learning and which decisions are STEM and context-dependent. Even more nuanced, I also aim to examine how the decision-making process reflects cultural, racial, and linguistic understandings of students from traditionally underrepresented populations in the context of STEM. Thus for this venture it would be helpful to receive feedback on the following:

a. What other frameworks inform decision-making of school leaders that impact STEM learning of students from traditionally underrepresented populations in urban contexts?
b. What questions could inform how the above pathways translate to actual science learning? For example, what aspects of the rational pathway are important for STEM learning and specific to cultural, racial, and linguistically diverse students?
c. What other pathways may be important to this specific vexation? Are these pathways more context, culture or STEM specific?

The overall goal of this venture is to outline a guiding framework that informs the decision making process of school leaders and how and why these decisions result in student learning and affirming experiences in STEM teaching and learning.

Nurturing Critical Consciousness in Urban Science Educators: Ain't Nobody Got Time for That

Brian Williams, *Georgia State University*

Vexation

> *Sometimes people hold a core belief that is very strong. When they are presented with evidence that works against that belief, the new evidence cannot be accepted. It would create a feeling that is extremely uncomfortable, called cognitive dissonance. And because it is so important to protect the core belief, they will rationalize, ignore and even deny anything that doesn't fit in with the core belief*. ~Fanon, 1967

This quote summarizes the essence of my vexation. Since its inception, the United States of America has declared to the world that it maintains a set of core beliefs grounded in ideals such as justice and liberty. However, the country has instituted policies and laws which support a system and culture of power that oppresses and suppresses entire groups of citizens on the basis of race, ethnicity, class, sexual orientation, and gender. These laws and policies are inspired by core beliefs set in ideas like white superiority, capitalism, and male dominance. Our nation's discomfort and resistance to changing these beliefs, even when presented with evidence to the contrary, has resulted in systemic inequities, injustice, and division in all segments of our society. The institution of public education in the United States continues to be shaped by these beliefs. As a result, entire groups of students continue to be underserved and marginalized by an educational system built around core beliefs that predict their underachievement. This is particularly true in science education, which appears to be one of the enduring bastions of systemic oppression in schools.

The beliefs referenced by Frantz Fanon also represent a particularly insidious obstacle in my students' pathway to becoming, first, critically conscious human beings and, second, effective teachers. My students often begin their careers steeped in beliefs that have been purposefully and methodically fed to them via a variety of modes including, but not limited to, mass media, institutions of education, popular culture, and community teachings. Consequently, they often adopt deficit-based perspectives such as colorblindness, the culture of poverty, and cultural deprivation as explanations for disparities in student achievement in science. Research has found that not only are teacher beliefs correlated to student achievement but, as a result of their beliefs, teachers tend to maintain lower expectations for students of color and students who come from poor communities (Eccles & Maddon, 1996; Ferguson, 2003; Rist, 2000). Consequently, addressing teacher consciousness is an important part of any effective teacher education or teacher professional development program.

For the past 14 years, I have worked to address this issue in the public educational system. My teaching, service, and scholarship have focused on preparing individuals to serve as effective elementary school educators in urban communities across the country. Because I am preparing my students to educate children who have historically been oppressed or marginalized by the public school system, I have situated my work at the intersection of science education and critical theory. Central to my efforts is facilitating the development of pre-service and in-service teachers' critical consciousness – their ability to identify and critique systemic inequities and work against them (Freire, 1970).

Fortunately, my work with pre-service teachers has been embedded in university programs. As a result, I have extended blocks of time to support teachers as they move from critical analysis to critical agency to critical action (Freire, 1970). The majority of my students graduate with a strong understanding of best practices in science education as well as a developing critical consciousness regarding equity and justice in public education. Unfortunately, they find few allies in this work at their school sites. As a result, they struggle to build on these ideas, beliefs, and practices beyond the walls of their individual classrooms. In terms of in-service teachers or leadership, schools are unwilling to invest the time and resources required for authentic shifts toward critical consciousness. Principals have argued that this work does not equate to higher test scores, better attendance, or less behavior problems, and is therefore lower on the priority list than professional development aimed at improving content knowledge, classroom management, or classroom teaching.

I am increasingly frustrated with the limited impact of my work. I am preparing pre-service teachers for school communities that do not value their understanding and commitment to equity and justice. Furthermore, I have not discovered effective strategies that (1) nurture critical consciousness among in-service educators and (2) address school leadership priorities. I work within and against historic systems of oppression deeply rooted in the fabric of the nation. My work is in resistance to these systems and their impact in my local community. I often wonder if, instead, I should be working with others around the nation to define new systems entirely.

Brian Williams, *Georgia State University*

Venture

My venture focuses on two main goals. First, I want to contribute to the proliferation of a popular narrative that embodies equity, justice, and inclusion in the scientific enterprise. I have been inspired by movements around the world that utilize decentralized networks, technology, research and scholarship, creative expression, and other tools to not only raise awareness about an issue but also mobilize communities to define new narratives and norms. Examples of such movements include Arab Summer, Black Lives Matter, and movements to deconstruct the prison industrial complex (e.g. the work of Bryan Stevenson). Each of these movements has successfully shifted narratives that were situated in specific communities (e.g. the academy, women, people of color) to the national stage. While the science community has also engaged in movement building (e.g. the March for Science), the work has focused largely on the marginalization of science by the larger, national community. Organizers and participants in this movement have neglected conversations related to equity, justice, and inclusion within the scientific community itself. As a result, inaccurate narratives regarding science persist. These include narratives regarding who participates in science today, who has contributed to science in the past, where our current understandings originated, who does science serve, what is the value of science in our world, what methods are utilized in the discovery and development of scientific knowledge, and what scientific knowledge is valued. By replacing these narratives with more accurate ones, we can begin to shift the consciousness of the larger community and build a foundation for critical agency and action in science and science education.

Second, I would like to develop specific strategies to address the consciousness of educators with regards to science. Current approaches to educator professional development in science tend to focus on improving pedagogical content knowledge or science content knowledge. Professional development aimed at addressing inequities or disparities in science education (often demonstrated by race, gender, and class gaps in achievement data) typically avoids work designed to address consciousness in exchange for sessions on equity-oriented pedagogy or culturally responsive pedagogy. As a result, the practice of teachers may change while the consciousness that frames their beliefs and expectations remains unaffected. As a result, teachers become better practitioners but continue to embrace ideals that deny some students access to that improved teaching.

I have begun developing strategies and tools to support these two goals. In 2018, I successfully launched Brian Williams Science, a website, and associated social media platforms. These digital platforms offer a space for conversations and sharing of ideas related to science and science education with an emphasis on narratives that are equity-oriented and inclusive. For the past five years, I have been working increasingly in informal education spaces that give me access to audiences that do not engage with my school or academy-based work. These spaces include local museums (Children's Museum of Atlanta), community organizations (e.g. the Boys and Girls Club), arts organizations (e.g. Kilgore Music Foundation), and corporations (e.g. Georgia Chamber of Commerce). Finally, I am also beginning work on a YouTube series aimed at encouraging a deeper understanding of and engagement in science. Each of these strategies represents my contribution to a larger movement around equity and inclusion in science education. However, this work must be connected to similar work if we hope to define a new narrative and inspire shifts of consciousness related to science and science education.

I am aware of other scholars, activists, and educators around the country whose work is well-aligned with my own. However, I am frustrated with the lack of coordinated effort. How do I begin to identify allies in this work and align our narratives, goals, and vision for science and science education? How do we move from pockets of siloed work to a national movement? How does this movement extricate itself from the confines of historic narratives and define new narratives for equity and justice in science that are not framed solely by resistance? How do we effectively share this movement and invite others to participate in it? These are the questions that I am seeking to answer.

Co-Design as a Vehicle for Equitable Science and Language Learning Opportunities for Emergent Bilingual Children

Carla Zembal-Saul with Michelle Brown, *Penn State University*

Vexation

In recent decades, rapid shifts in demographics associated with immigration to the United States have affected the cultural and linguistic composition of communities with little recent history of ethnic or racial diversity (Wortham, Murillo, & Hamann, 2002). In fact, by 2025, emergent multilingual (EM) students are expected to comprise one-quarter of the overall US school population (Suárez-Orozco, Suárez-Orozco, & Torodova, 2008). Research suggests, however, that most general education teachers feel underprepared to work with EMs (Gándara, Maxwell-Jolly, & Driscoll, 2005). This is problematic given that teacher quality and preparation remain the strongest school-related predictors of achievement for all students, including EMs (López, Scanlan, & Grundrum, 2013). Thus, it is critical to identify approaches that support teachers' professional learning related to EM instruction, especially in new immigrant destinations where capacity to do so tends to be most limited (Lowenhaupt & Reeves, 2015).

STEM education, and science in particular, offers authentic opportunities for productive classroom discourse associated with investigating phenomena, constructing and critiquing evidence-based models and explanations, and negotiating and using scientific ideas and vocabulary (see Hooper & Zembal-Saul, and Zembal-Saul & Hershberger, in press). Such discourse opportunities support sensemaking and language development for all children, especially EMs (Lee, Quinn, & Valdés, 2013). Unfortunately, equitable access to discourse-rich science teaching is not common in most US classrooms, particularly in the early grades (NASEM, 2015).

My research team and I are currently working in a community that is experiencing dramatic demographic shifts. The school district is located in a mid-size, semi-urban city in the Northeastern United States. Over the last ten years, the city's Latinx population increased from 0 to 40 percent, and the districts' EM population increased from 1 to 15 percent. Most new families to the area are from the Dominican Republic and Spanish is their home language. Like many school districts in new immigrant destinations, the capacity and resources to meet the needs of culturally and linguistically diverse learners are often sparse, especially in STEM (NASEM, 2018) – district and school leaders have scrambled to respond. The district has no formal science curriculum in the early grades. In grades 3-6, the science curriculum is highly prescribed and textbook-driven, leaving little room for science teaching and learning that is focused on sensemaking. We see this void as an opportunity to leverage science as the academic content around which to engage district teachers, families, administrators, and other education professionals in creating equitable and consequential language learning opportunities for EMs.

Not surprisingly, most educators in the inner-city schools of this district are white, middle class, monolingual English speakers. They are not used to outside collaboration and are suspicious of outsiders. My vexation focuses on supporting teachers' professional learning in this complex and racially charged setting. While I have designed and implemented professional learning experiences for elementary teachers that focus on sensemaking in science throughout my career, I have never worked in a new immigrant destination. While a focus on engaging children in productive discourse and scientific practices can be a tall order for many elementary teachers, the context requires that every child, including EMs, be seen as having rich cultural and linguistic resources that are both important and relevant for engaging in scientific practices and learning English. Put another way, the challenge is not only to couple sensemaking in science and language learning, but also to do so in ways that position students and their families as capable knowers and knowledge builders.

Venture

I am currently the project director for ***Science 20/20: Bringing Language Learners into Focus Through School–University–Community Partnership*** (DOE, OELA, NPD, 2016) (Hopkins, Zembal-Saul, Lee & Cody, in press). After a period of information gathering and planning, my team and I have piloted an initial cycle of professional learning for elementary teachers, made modifications, and implemented another cycle. While we initially used a practitioner inquiry model with teams of teachers, parents, and afterschool educators, we regrouped in 2018-19 to build capacity within each group of partners.

To facilitate teachers' understanding of the foundational principles of the project – students and families as partners in knowledge building, productive participation in sensemaking discourse, and formative assessment – we designed and continue to refine Science 20/20 as an intensive professional learning experience. There are three institutes throughout the year (i.e., summer, winter, spring) in which teachers are introduced to project principles and associated practices. A continuous focus on these principles is intentional and allows us to foreground attention to equity in all aspects of our work with teachers and students. In addition to formal institutes, project personnel meet weekly with groups of teachers in their classrooms. School-based professional learning involves multiple cycles of project implementation and co-design throughout the year.

The co-design of resources for use by other educators who teach EMs (e.g., video cases, briefs) by teachers and researchers demonstrates promise as collaborative and productive context for raising sensitive questions and practitioner inquiry. The co-design process (Penuel et al., 2007) involves teachers as collaborators in shaping how ***Science 20/20*** will play out in their classrooms. Co-design involves multiple cycles of collaborative work that include:

- Planning instruction and assessment based on project principles;
- Teaching and documenting student learning;
- Analyzing samples of student work to inform subsequent instruction; and
- Creating, implementing, and refining instructional tools and resources.

Weekly interactions are intended to be responsive to teachers' in-the-moment needs and questions, and ultimately keep ***Science 20/20*** work at the forefront of their thinking and practices as the demands of the school year unfold.

Initial resources and tools suggest that co-design is a promising practice, not only for leveraging science practices and language learning, but also for creating opportunities for teachers to see emergent multilingual children as having rich funds knowledge. While I am interested in teachers having a voice in how new initiatives impact practice at the classroom level, I am equally hopeful about how co-design influences their perceptions of emergent multilingual children and families. I hope to pursue this line of inquiry further in my research and practice and seek the support of the Crossroads community to consider how to ensure each round of co-design intentionally requires attention to equity.

a. Although EM students are at the forefront of this work, a lot of our time is spent working with teachers. How can we best involve EM families both in understanding the work we do and inviting their input and collaboration when trust between EM families and schools (and therefore, Science 20/20) is tenuous and the teachers we work with use language that aligns with deficit perspectives?

b. How do we navigate authentically co-designing resources with teachers around EM children and families, while making sure resources align with critical consciousness and funds of knowledge?

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