Science Education at the Crossroads

Alta Lodge, Utah • October 11-13, 2018

WELCOME!

Dear Crossroaders,

It's a pleasure to welcome you to our 2018 meeting.

This is an odd thing to write, since we composed this Welcome far in advance. This gives the ink time to affix to the page, for the pages to be bound, and so this volume can be delivered to your door. And yet, here it is, this strange warping of time and space that bridges us together. At the time of this writing, we've just confirmed final preparations at Alta, and Adam has set foot upon the property, arranging a few tables and checking on the progress of the changing aspen leaves. All seems to be in order.

But the main ingredient in all of this is you. We know, we say this all the time. Those of you who have joined us before have heard this refrain, and those of you yet to get to know us will get used to this tune: we host this meeting because it's the conference that *we* wish to attend. You just happen to be what makes it all possible, in addition to the aspen leaves. Make no mistake, though. We've come to realize that Crossroads is not just a gift to ourselves, but an investment in all of us. We see work deposited here that pays dividends in ways we never can predict or even imagine. People move, launch new career paths, innovate personal practices.

We have a particular nostalgia for Alta that dates back to our meeting in 2008. In part it's because we have a collection of photos from that meeting in particular, and these engrain themselves in the psyche. There was an address from Heidi C. about the impact of Crossroads up to that point, which seemed so consequential even in 2008. There were stories from our friend Bhaskar U. that tied us back to his childhood, a Nepalese landscape, and images of boys riding water buffaloes. There was the poem and the bottle of scotch that Scott M. contributed, and both brought people to tears. There were name badges written by the hands of first graders, crayons wrapped with small, tightly clenched fingers. There were beginnings of careers that are now in full swing, as well as the contemplation of the ends of others. There was snow that Sunday morning as people assembled into shuttles and shared cars. All this and so much more.

This gathering of 2018 has so much to live up to, both resulting from our expectations and from the memory of what happened here before. Yet, there's no pressure in this. What you see in the following pages of these Proceedings represents the work already elevated to 8000 or so feet above sea level. We're excited to see what comes of all this, and we're excited to engage in it all with you.

Adam & John

Program Schedule

Thursday, October 11

noon – 7:00 pm	**Arrivals**	Alta Lodge, 10230 E Hwy 210, Alta, UT 84092	
7:00 – 8:00 pm	**We Begin**	Reception, Welcome, and Orientation Adam Johnston and John Settlage	**Deck Room**
8:00 – 9:00 pm	**Poetry**	My Favorite Poem Readings *Assorted Volunteers*	**Deck Room**
after hours	**Networking**		

Friday, October 12

9:00 – 9:15 am	**Welcome**	Re-Welcome & Fresh Introductions	
9:15 – 10:15 am	**Keynote**	Playing One Another's Songs Adam & John	
10:15 – 10:45 am	**Break**		
10:45 – noon	**Incubator A**	Melissa Braaten & Nate Wood (w/ Vikki)	**Dining Room**
		Andy Gilbert & Karen Lionberger (w/ Caitlin)	**Sitzmark**
		Kathryn Hayes & Ed Lyon (w/ Julianne)	**Powder**
		Mark Enfield & JT Taylor (w/ Kasper)	**Deck**
noon – 1:29 pm	**Lunch**		
1:30 – 2:45 pm	**Incubator B**	André Green & Amanda Gunning (w/ Kasper)	**Sitzmark**
		Meredith Kier & Stephany Santos (w/ Vikki)	**Powder**
		Jessica Dwyer & Angela Johnson (w/ Caitlin)	**Deck**
2:45 – 3:30 pm	Break		
3:30 – 4:45 pm	**Incubator C**	Malcolm Butler & Rachael Gabriel (w/ Kasper)	**Powder**
		Elaine Howes & Greg Rushton (w/ Vikki)	**Deck**
		Adam Johnston & Jim Middleton (w/ Caitlin)	**Sitzmark**

4:45 – 7:29 pm	**Free Choice**	With Recommended Dining Options
7:30 – 8:00 pm	**Treats**	Dessert Reception
8:00 – 9:00 pm	**GUEST SPEAKER**	**Ron Proctor**: *Stringing Together Art and Science*
after hours	**Chatting**	Keep the conversations going

Saturday, October 13

9:00 – 10:15 am	**Incubator D**	Tyson Grover & Stefani Marshall (w/ Vikki)	**Deck**
		Cheyenne Herlandsteain & Alexis Patterson (w/ Caitlin)	**Sitzmark**
		Seema Rivera & Teresa Shume (w/ Kasper)	**Powder**
10:15 – 10:45 am	**Break**		
10:45 – noon	**Incubator E**	Melissa Mendenhall & Julianne Wenner (w/ Caitlin)	**Powder**
		Asli Sezen-Barrie & Leigh Smith (w/ Vikki)	**Sitzmark**
		Ying-Chih Chen & Eleanor Sather (w/ Kasper)	**Deck**
noon – 1:00 pm	**Lunch**		
2:00 – 3:00 pm	**Debriefing**	Follow-Up Discussion of the Crossroads Alta Experience	
3:30 – 11:30 pm	**Ongoing Ventures**		

Sunday, October 14

9:00 – 9:15 am	**Brunch**	Re-Welcome & Fresh Introductions

RON PROCTOR

2018 Science Education at the Crossroads Guest Speaker

Ron Proctor is an animator and film producer, serving as Clark Planetarium's Production Manager and as an independent producer with his company, *Physics Foundry*. Ron began working in the planetarium industry at Weber State University's Ott Planetarium in 2003 and has been with Clark Planetarium since 2014.

Ron holds a Bachelor of Integrated Studies in Physics, Communication, and Multimedia (2009), and a Master of Education in Curriculum and Instruction (2014), both awarded by Weber State University. Ron also studied 3D modeling and animation at the Ogden-Weber Applied Technology College. Ron now specializes in Blender, a free, open source 3D software. Ron offers a Blender tutorial series on YouTube and occasionally offers live Blender workshops.

Ron's recent film projects include Physics Foundry's ***Eclipses and Phases of the Moon***, Clark Planetarium's ***Black Holes***. Ron is currently directing the production of Clark Planetarium's ***The Edge***. His team also develops interactive software for Clark Planetarium's exhibits program – these, along with his film projects are distributed to museums and planetariums around the world. Ron Proctor lives with his partner, AmyJo; two children, Rigel and Tony; and a flock of chickens in Farr West, Utah.

Stringing Together Art and Science

By day I make video games and 3D animation for a science museum; by night I make cigar box guitars. I have a high-tech job and a low-tech hobby – tech-life balance, I suppose. While it's nice to unplug and make something with your hands, I make guitars because I got the blues in me and I need a way to let em out.

Incubator Sessions

With the goal of nurturing and hatching grand plans, we call the sessions Incubators. Each Incubator includes two presenters and an audience of self-selected participants gathered around a conference table. Each Incubator session is scheduled 75 minutes with timekeeping monitored and maintained by a Facilitator. Allowing for a small amount of transition time between presentations, each presenter has exactly 35 minutes set-aside and that time follows this very precise schedule and sequence:

- 10 minutes for the presenter to describe the vexation/venture (without interruption)
- 5 minutes for the participants to ask clarifying questions of the presenter (with responses from the presenter)
- 15 minutes for the participants to discuss the venture/vexation of the presenter (without any input from the presenter), and finally
- 5 minutes for the presenter to speak, respond, ask questions, etc.

In the schedule, not only are the Presenters listed for each Incubator but also a designated Facilitator. Whoever is the Facilitator in a session, there is one thing to know: their word is the law.

The Facilitators

Crossroads relies upon a specific structure to scaffold conversations while also liberating your minds. The presence of a Facilitator in each session is crucial because that person is responsible for maintaining a climate environment that benefits everyone from the Incubator sessions. They are best characterized as endearing taskmasters. Facilitators for the 2018 Crossroads are volunteering their time to assist in this event and their efforts make all the difference. We grateful acknowledge their involvement.

Vikki Gaskin-Butler	**Victor Kasper**	**Caitlin Fine**
Univ. of Central Fla.	*Florida State*	*Univ. of Colorado*

Incubator Etiquette

We discourage moving between rooms during an Incubator. While such practices are common at other conferences, here it reduces trust-building and disrupts idea exchange.

We encourage a uniform distribution across sessions. If you notice a crowded or sparsely populated room, consider doing your part to balance the numbers across meeting spaces.

Citing Your Paper

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

Your name. (2018). *Title of your talk*. Paper presented at the annual meeting of Science Education at the Crossroads, Alta Lodge, Utah, October 11-13. www.sciedxroads.org/proceedings2018.html.

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

Your name. (2018). Title of your talk. In J. Settlage & A. Johnston (Eds.), *Proceedings of the 2018 Science Education at the Crossroads Conference* (pp. xx-xy). Alta, Utah. [Available online at www.sciedxroads.org/proceedings2018.html].

Melissa Braaten, *University of Colorado*

Vexation

Over the past 7 years, I have been working closely with K-12 teachers in their schools and districts across three different states. This close partnership and immersion in the organizational contexts of teachers' workplaces has been essential for understanding how institutional, structural, and political contexts diffuse through teaching and shape teachers' professional lives and identities.

My partner schools and districts are all facing accountability pressure in the form of mandatory "data driven" goal-setting lead by district or state authorities who decide: 1) a specific subgroup of students to "target" as the central problem for a school to address, 2) a specific benchmark in an academic subject as the focal goal that must be met or the school will face sanctions, and 3) a specific mandatory teaching practice that must be used as the means for accomplishing the goal. For example, in one middle school this meant that all teachers were expected to focus specifically on African American boys with low past performance on Literacy interim assessments and state assessments. All teachers were required to use a specific Close Reading strategy to work on changing this outcome (Bradford & Braaten, 2018).

This "data driven" accountability and improvement context has raised a number of vexations for me and for my partner teachers because these practices have defined – without deliberation or sense-making with teachers – a certain way of thinking about equity, a way of prioritizing certain disciplines over others, and a way of prioritizing certain pedagogical approaches over others. I'm troubled by how these data-centric accountability efforts undermine any progress that our research-practice partnerships had been making toward more equitable science education (Braaten, Bradford, Kirchgasler, & Barocas, 2017).

My current vexation emerges from a pattern that I've seen across many of the science teachers with whom I work. Many of these teachers were vocal, at least initially, about questions and sometimes downright objections to the uses of data, goal-setting, and formulaic teaching set forth in their schools and districts. Teachers' resistance came in many forms as teachers pushed back subtly by doing things like "Close Reading" the graphs, paragraphs, and diagrammatic models that students generated during science learning experiences even though these "texts" were not recognized as texts by administrators during walkthrough observations. Other teachers' resistance was more overt, or as one teacher asserted, "civil disobedience" in refusing to lecture or have kids read from an authoritative text in a modeling-based physics classroom. But over time, their resistance waned and so did their sense of agency as teachers.

In our interviews, these teachers described feeling that they were slowly being stripped of their ambitious teaching practices and of the moral center for their work. They described feeling untethered from professional goals and identities. Santoro (2018) captured this same phenomenon among many teachers' experiences of the increase in accountability efforts in schools and the tightening of management approaches to schooling. She calls this phenomenon *demoralization* and argues that demoralization can drive teachers' dissatisfaction with work and workplaces to such an extreme degree that teachers who had previously shown remarkable commitments to students and to the profession begin to withdraw and potentially leave the profession altogether. I am seeing this same pattern happening among the teachers that I'm working with and it is the problem that I want to solve next.

In his studies of how subordinate groups push back against oppressive systems and exert political agency against oppressors, Scott (1990) offers an analysis of how resistance operates suggesting that subtle, hidden forms of resistance are important forms of political agency that can be amplified and made into effective points of change if people band together so that subordinates find protection within oppressive systems. In public discourse about teachers and the current teacher collective actions taking place across the country these ideas are gathering momentum as teachers seek out more of a voice in their workplace conditions and band together to press for change. I want to capture and fuel similar momentum with my local partner district where there is a small, but growing, group of teachers who want to band together to work for change in their science teaching and change in the ways that equity and social justice are portrayed in their "data driven" schools.

Venture

In her study of teachers who were leaving, or considering leaving, the profession they love, Santoro (2018) offers the concept of re-moralization as a hopeful contrast to her findings about teachers' demoralization. Re-moralization, or "the ability to access and conserve the moral rewards of their work," can happen if teachers are able to take specific actions that are personally meaningful within the particular workplaces and situations where teachers work (p. 5). Unlike "resilience" or other individual psychological remedies offered for "burn out", Santoro is arguing for a much more active, often political, pathway where teachers are able to lead the way towards important changes for students, teachers, and the profession: "Teachers' professional moral centers may require that they push back with resistance rather than bounce back with resilience" (p. 109). Santoro's research suggests that remoralization can happen through a variety of inter-related pathways including: 1) taking student-centered action, 2) enacting teacher leadership, 3) engaging in teacher activism, 4) being recognized as having a voice in education, and 5) working within a professional community with shared commitments.

I, too, am seeing how teachers can take action together to reclaim the values, purposes, and commitments that drive their work. At the start of this school year, for example, my 5th grade teacher partner, Mrs. Champion designed a series of school-wide professional learning experiences with her colleagues to capitalize on newly adopted science standards in our state and use this as a reason to reignite K-5 science in her school. She is anxious about this venture: Will she have enough support and resources to juggle this leadership venture alongside her own teaching responsibilities? Will her colleagues experience the same kind of re-energizing feeling that she felt when she focused on improving science teaching and learning in her classroom? Mrs. Champion, her principal, and her colleagues are embarking on something exciting together, but it is also a subtle act of resistance because the district is not yet ready to support their shift in practice. Instead of waiting patiently, Mrs. Champion and her colleagues are charging ahead.

I want to help my school/district partners create a science teacher leadership collective so that teachers can work together for ambitious and equitable science teaching in grades K-8. I also want to capture the work that we do together in the form of a toolkit or a set of resources and examples that could be used by other teachers or district personnel to foster similar leadership collectives elsewhere. But, I have no idea how to get started and how to avoid potential pitfalls that could arise. For instance, I'm not sure how to create leadership collectives – teams where leadership is shared among all of the players – instead of leadership hierarchies where individual teachers are singled out as "leaders" and their relationships with colleagues begin to suffer (Wenner & Campbell, 2017). I'm also unsure about how to support teachers in their acts of resistance when their interest in science education and their definition of equitable, humanizing science education comes into conflict with their principals' or with district leaders' views of "good" teaching, learning benchmarks, and continued focus on accountability.

For the past year, I have been organizing a small group of elementary teachers who are passionate about creating meaningful science learning experiences for their students, regardless of curriculum constraints and accountability pressures. It is not that these teachers truly disregard curriculum constraints or accountability pressures; instead, it is that these teachers are not willing to sacrifice meaningful science education in exchange for mundane curriculum or exclusive focus on reading and mathematics scores. As part of this work, one elementary school principal (Mrs. Champion's principal) is also interested in pushing beyond the constraints of the current system to venture forward and create school-wide science learning experiences that are humanizing, exciting, and meaningful for children. However, I am also trying to be mindful of district-level coaches and other district-level leaders whose jobs as educational leaders are often ambiguous and deeply constrained. Their work often seems frozen in inaction as science education efforts are tabled in favor of efforts valued as higher priorities by other district leaders. Herein lies my dilemma – must we have consensus and agreement across all levels of a system or is there a way to support productive resistance, agency, and innovations while maintaining a healthy partnership?

Living While Black

Malcolm B. Butler, *University of Central Florida*

Preamble

Living with a seemingly omnipresent media, it would be difficult to NOT be aware of the stories of Blacks being abused and mistreated. Science educators and scientists are not immune from these unfortunate situations and experiences. Concomitantly, it is also important to celebrate the economic and social gains that some Blacks have earned. I feel and think about these two unique sets of occurrences as examples of how far the US has come in race relations, and yet we should acknowledge how significantly farther we have to go. As a professor, neighbor, son, brother, husband, father, colleague, friend, and fraternity brother, I am concerned with the direction we are headed as a society, and not just the lack of progress specifically, but more so the regression that is happening. In this paper I will further describe my vexation and offer some ventures I am undergoing and considering to make this world a better place. I will also move away from one of the most common indicators of a scholar —citations and references. I have not written such a missive in quite some time, so it will be quite the challenge. Nevertheless, I am taking on this mental challenge.

Vexation

One of many irritations I come up against on a daily basis is that many of us as human beings, spend most of our time focused on "human doings." My father-in-law preached about this concept and concern many years ago, and the message has resonated with me since then. His thoughts aligned with my space and experiences at that time and continue to provide food for thought. My annoyance has more to do with me than others: I am responsible for how I spend my waking hours — being or doing. Yet, the more I try to be, the more I find myself doing. So it is with being Black, or doing/living while Black (LWB). As a Black professional cisgendered male, I am constantly challenged to reconcile being Black versing "doing" Black. Both are a part of this LWB life. When I wake in the morning, I challenge myself to be the best Malcolm, while acknowledging that some people I encounter in the day will want something different of me, many times with the backdrop of Blackness expected to be brought to the forefront. So, let me share some spaces where, on a daily basis, LWB comes into play for me.

LWB in the Academy

As one of fewer than 60 Black Science Educators in the US, I note that our plight is unique to institutions of higher education, especially when the majority of these scholars work in Predominately White Institutions (PWIs). Colleagues have studied and written about the situation, putting science education in the larger context of Blacks in colleges and universities.

If a unicorn is rare or doesn't exist, imagine the status of a Black Unicorn.

The overburdened obligation to "be Black for me." More human doing than human being.

The "You are not like the rest of them" syndrome.

LWB in the Community

Neighbors who speak; many who don't. Some who recognize humility when they see it, and others who don't. Stereotypes abound but rarely subside.

LWB in the Family

Expectations of the church family, fraternal family, and nuclear family. Called on to hold up the light for all to see as, an example of what can and should be.

The three aforementioned LWB settings are unique in how I interact with members of the communities, and there are certainly overlaps between the people and the norms in each community, but sometimes "only the names change" when it comes to the expectations of and assumptions made about me, especially as a Black academic. I don't suppress any aspect of whom I am in these settings, but I must be conscious of how I am perceived in each environment.

Ventures

In my attempts to reconcile my LWB dilemma/blessing, I take a bimodal micro and macro approach. While this approach is not fail-safe, it does provide me with the means to navigate the three aforementioned spaces. Thus, I consider my inner workings as an individual (micro approach), while simultaneously addressing those matters that arise in the equally-valued communities of life (macro approach).

Internally (Micro Approach)

Three approaches:

a. Being okay with me; not the best me all the time, but the better me getting better.
b. Staying reflective.
c. Being circumspect.

Externally (Macro Approach)

Three approaches:

a. Finding kindred spirits, knowing that "Every color ain't your kind."
b. Being open to diversity of thought, experiences, and solutions.
c. Staying eclectic.

I will continue to seek to function in an ecosystem where humans are a part of the it, not in control of it. Part of my journey will include consciously and subconsciously helping others to see value in all peoples. I won't be perfect at it, and I need to be okay with that.

My Blackness is an important part of who I am, yet not nearly all of who I am. For example, I am a senior faculty member at a large university (over 67,000 students!) that will soon become a Hispanic Serving Institution. I am also considered a scientist (indeed a physicist!) in some circles, called upon to use my scientific training and background to help solve problems and provide insights. I am a formal mentor to two amazing colleagues (neither a Black male), and the list goes on and on. And that's just in the academy community!

I find value in all of these aspects of my professional life, so nothing in my life is immune to my doing and being. Surely scientists and science educators get it. And yet there have been times when I clearly remember where they did not understand. But I don't let those mishaps deter me from being and doing. It would be detrimental to my growth if I lose sight that my LWB may be no different than others who are challenged to function in a world where certain aspects about them are foregrounded (e.g., an atheist in a religious community, a same sex couple interacting with a school about their child, etc.). For this brief moment in time during this Crossroads incubator, I just want to bring attention to the current state of affairs for me and many others who are LWB. Just know that I will continue to seek to be a human being as I live in a world much more focused on humans doing.

Uncertainty management in argumentation: Resources, productiveness, and teacher knowledge for and in practice

Ying-Chih Chen, *Arizona State University*

Vexation

I have been an optoelectronic engineer over five years before jumping into the arena of science education. The experience of being an engineer and collaborating with "pure" scientists helps me understand how science works and how science connects to engineering and knowledge development. One element is uncertainty management: how we identify uncertainty's source, adapting the uncertainty to advances discussion, and resolving uncertainty toward final products and knowledge development. Thus, science and engineering is about managing uncertainty. Scientists not only identify uncertainty, but also sustain and eventually find solutions to "seek certainty." Scientific and engineering practice as uncertainty management is fundamental enterprise of science.

My work with scientific argumentation suggests that argumentation is a core practice of science inherent with uncertainty. Students with diverse or opposed claims attempt to debate, persuade, and evaluate each other in order to establish a consensus within a community. Uncertainty creates a platform for students to discuss, debate, and debunk and further extends their knowledge. Most researchers in science argumentation have focused on: (1) a practice of structuring arguments (Osborne, Erduran, & Simon, 2004; McNeill, 2011), (2) argumentation as a process of justification, persuasion, and sense-making (Berland & Reiser, 2009; Ford, 2012), (3) argumentation as representations of disciplinary concepts (Chen, Park, Hand, 2016; Waldrip & Prain, 2017), (4) argumentation as development of scientific literacy (Cavagnetto, 2010), and (5) argumentation as a practice of reasoning (Salder, 2004). Relatively few studies have explored argumentation as an enterprise of uncertainty management. Current literature, include my work, says little about the role of uncertainty and how teachers manage uncertainty within argumentation that leads to conceptual development. If we expect argumentation to emerge from uncertainty activity, if we expect our students to engage in what scientists do, and if we expect to maximum the success of argumentation in student learning, we should know where, how, and what moments productive uncertainty may be raised, and what resources of resolving uncertainty teachers and students can take up.

As a science educator, I have opportunities to work with pre-teachers through methods courses and in-service teachers through professional development. It is very challenging to help teachers understand the value of argumentation as an enterprise of uncertainty management. I have three vexations as follows:

1. ***Resources* of uncertainty management:** What are the critical uncertainty managing resources when students are engaged in argumentation — and how do those contribute to knowledge development?
2. ***Productiveness* of uncertainty management:** How do teachers create productive conditions for raising, maintaining, and reducing uncertainty that ultimately lead to students' knowledge development?
3. ***Knowledge* of uncertainty management:** What are the characteristics of teachers' knowledge of uncertainty management in argumentation, including declarative (knowledge *for* practice) and dynamic (knowledge *in* practice) knowledge, when they implement argumentation in their classrooms?

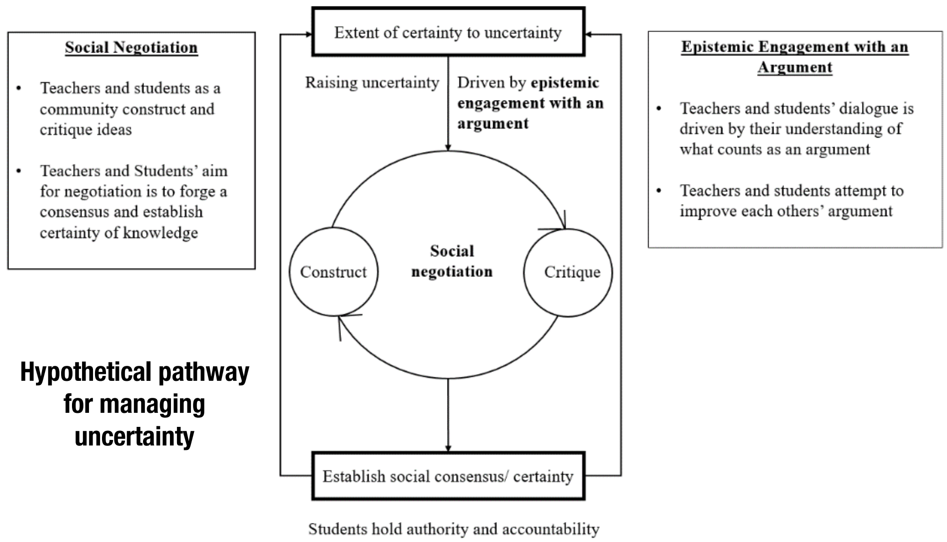
Venture

I have a venture to address the vexations and want to hear what Crossroads participants think.

Resources. We need to help teachers to identify resources that help create uncertain moments and one such resource is students' *epistemic understanding of argument*: understanding what counts as claim and evidence. Students are usually uncertain when they "interact with evidence as they engage in classroom work and seek to make sense of investigations" (Manz, 2015, p. 1116). Nevertheless, argumentation is more than "argument." Another major resource is students' *social negotiation*, referring to actions students publicly construct and critique each other arguments (Chen et al, 2016). The social nature of argumentation requires posing questions and exploring uncertainty by challenging, debating, debunking, and supporting diverse ideas. Social negotiation allows students to express their uncertainty as a community collaborates to solve uncertainty. From this point of view, *social negotiation* becomes a resource that stimulates awareness, maintenance, and reduction of uncertainty to progress and improve knowledge.

Productiveness. To productively use the resources to raise, maintain, and reduce uncertainty, I propose a hypothetical pathway that may create a space that thus open up co-construction opportunities for students where argumentation is taken up and uncertainty is wrestled with by both teacher and students. The figure shows the hypothetical pathway.

Knowledge. I am borrowing Shulman's (1987) pedagogical content knowledge to start: (1) knowledge of students' understanding in science and (2) knowledge of instructional strategies and representations. Most PCK research solely focuses on knowledge-*for*-practice which Alonzo and Kim (2015) call the *declarative* form of PCK. However, a lesser-known "*dynamic*" nature of PCK which is knowledge-*for*-practice. Avraamidou and Zembal-Saul (2010) suggest that coherent PCK for argumentation requires both forms of knowledge. My project adopts PCK in argumentation as including not only declarative knowledge (knowledge-*for*-practice), but also dynamic PCK (knowledge-*in*-practice). Table 1 describes the interaction between these two aspects of uncertainty management in argumentation and the two components of PCK.



Hypothetical pathway for managing uncertainty

Matrix of Two Aspects of Uncertainty Management in Argumentation & Two components of PCK

PCK / Resources for Uncertainty Management	Knowledge of Students' Understanding in Science	Knowledge of Instructional Strategies and Representations
Epistemic Understanding of Argument	Knowing (declarative) and able (dynamic) to adapt the uncertain resource of students' strengths, weaknesses, difficulties in interpreting data as evidence, use of evidence to support claims, and construct coherent arguments.	Knowing (declarative) effective strategies that utilize students' uncertainty of argument as resource and are able (dynamic) to use the strategies to scaffold students to search for patterns of data leading to evidence, distinguish weakness and strengths of the structure of arguments, and revise arguments.
Social Negotiation	Knowing (declarative) and able (dynamic) to adapt the uncertain resources of students' strengths, weaknesses, difficulties in engaging debate, defending, debunking, and revising arguments in order to establish a consensus.	Knowing (declarative) effective strategies that utilize students' uncertainty of argument as resource and are able (dynamic) to use the strategies to scaffold students to discuss diverse arguments, consider a counterargument, and coordinate different ideas to reach a consensus.

I have just begun this work and there are a number of questions I am struggling with and turn to my Crossroads colleagues for feedback and compassionate critique on the following:

1. Do you consider a role of uncertainty in science learning? How can uncertainty be means to support students to learn science?
2. How might we introduce uncertainty in science to pre-service teachers and help them to incorporate it into their teaching?
3. How can we present uncertainty to in-service teachers? Is uncertainty an appropriate terms to discuss with teachers?

When Do We Name It?
Explicit v. Implicit Equity and Inclusion in an Undergraduate Learning Assistant Program

Jessica Dwyer, *University of Utah*

Vexation

I became a teacher as an extension of my belief in Rumi's assertion that "everything is about loving and not loving." Through my decade in highly-impacted Title 1 schools, however, I watched my own pedagogy degrade away from the primacy of relationships and towards a results-based metric which increasingly invited me to ignore, or even reject, my students' integral humanities. In the intervening years between then and now, I've learned to frame my shift as one of classroom collaborator to classroom colonizer. I share this realization in the spirit of a shift in academy-based research encouraging practitioners to articulate, before their aims and hypothesis, their commitments and positionalities (Kovach, 2015). I return, now, to a very different classroom context, newly renewed to privilege authentic relationship and an unflinching commitment to the messy, complex work of building a truly inclusive academy. I do it, however, without a PhD, and with a group of humans that has not previously conversed, nay 'worked,' in spaces aimed at equity, inclusion, and the requisite redistribution of power and privilege that that work demands.

Undergraduate STEM education at the University of Utah consistently demonstrates frustrating and unacceptable trends in student outcomes. The enrollment, persistence, and graduation rates of students from historically underserved groups in STEM coursework/majors does not reflect the demographic profile of the student body (let alone the Salt Lake Valley). Contributing to the complexity this challenge is the R1 institutional structure/culture, itself. Because tenure-track professors and teaching assistants are neither trained in nor incentivized to teach utilizing evidence-based instructional practices, lecture-centric, confirmatory lab models currently continue to dominate our undergraduates' experiences.

The University of Colorado at Boulder initiated the Learning Assistants program 12 years ago. This innovative approach supports professors' exploration of pedagogical improvements to include more active learning approaches. Learning Assistants are undergraduates who have been "successful" in a given course (in quotes as success can be defined differently depending upon program goals, student strengths and positionalities, etc.). Initially implemented in classrooms where professors were attempting to 'flip' their instruction, but then were challenged to lead 300-person discussion sections, LAs were deployed to assist several groups of students in small-group discussion. LAs also enrolled in a pedagogy course to build their capacity to plan for, facilitate, and evaluate the efficacy of the small-group discussions they lead. The LA model is wildly successful across multiple measures; beyond increasing retention and academic achievement of historically underrepresented students, LA programs also improve academic outcomes for the LAs themselves, and motivate significant shifts in professors' use of active learning strategies. The three key components to a bona-fide LA program include: regular opportunities for LAs to facilitate content-based, student-centered discussions, a weekly prep meeting with the instructional team (course professor and TAs), and a pedagogy course (Otero, Pollock, and Finkelstein, 2010).

The U has utilized elements of an LA program for years, organically, via intrepid individual instructors. 2017-18 was the first year that all three program elements were in place. I taught the pedagogy course (SCI 5050 - The Science of Learning). I welcome and celebrate what Dr. Valerie Otero at CU calls the 'stealth' capacity of an LA program to improve institutional equity and access for underserved students. Breaking with Dr. Otero's advice, however, I unilaterally added decidedly non-stealth, explicit explorations into institutional oppression and individual bias in impact on student outcomes in my syllabus. I have taught this semester-long course twice. Twice, I have had a surprising(ly negative) experience *at the same point* in the course; in exploring how social power structures can manifest in group work: twice, my best-effort facilitation of a difficult discussion was interpreted by a student as a hierarchy-supporting, relationship-violating maneuver. While this micro-pattern demands my own exploration and reflection, it also invites macro-questions that drive program design: ***what is the role of explicit social justice data, scholarship, and experience in content-based instructional interventions? is this type of agitation/unavoidable discomfort requisite for lasting social justice outcomes? how woke do folx need to be in order to facilitate equitable instruction?***

Venture

The U's LA program is at a particularly formative moment; several departments are actively exploring the model, instructors are requesting pedagogical training to support their effective use of these amazing undergraduate assistants, and university leadership recognizes LAs as an effective tool to positively impact instruction. Because of this, there is a window of opportunity to co-create program assumptions and norms that may perpetuate throughout the program's anticipated long lifespan.

Beyond teaching SCI 5050, I have been asked to generally lead LA program administration – an opportunity both perfect and maddening. The perfection lives in the intersection of components; not only does this program address many components of education to which I've dedicated my own scholarship, practice, and efforts, but I am also in-process in earning a 2nd Master's in Social Work towards deepening my understanding of, and efficacy in positively impacting, person-in-environment analysis of social inequities in education with a skill-set specifically crafted to facilitate organizational scale change through partnership cultivation and capacity building. The maddening piece is the intersection of my own intellectual understanding that enduring institutional shifts are slow with my own internal, compulsive tendency to, in general, move very, very quickly. I recognize that, in my impatience, I risk pushing, offending, and social-justice-warrioring-to-death potential allies in the College of Science (both Learning Assistants and faculty) who are generally well-meaning but who have deeply different perspective than I do.

I propose a tiered structure, a sort of buffet of levels of engagement which, if pursued, may lead LA Program-affiliated practitioners to first name, then act upon, the components of colonization and white supremacy undercurrents that stain our dominant organizational structures and decision-making methods.

Program Element	Surface Engagement	Results-motivated Engagement	Self-Reflective Engagement
Faculty Support	Intro 3 components via: ▪ Orientation workshop ▪ Online resources ▪ Online discussions	Celebrate: ▪ student improvement data ▪ instructor best-practices ▪ any risk taking Then offer selected resources to explain results from a S.J. frame	*Patiently wait for opportunities to:* ▪ build a "veteran instructor" journal club, and offer to construct bibliography ▪ invest in conversation
SCI 5050	Emphasize pedagogical strategies and the neurophysiology which informs them.	Universality of Imposter Phenomenon experience. Optional opportunities to explore impacts of power and privilege. Prioritize student choice in topic exploration.	Use final poster session as a chance to target specific students, based on their own expressed preferences, to explore "less stealth" ideas
Institutional Integration	Collect data which speaks to many stakeholders, particularly regarding financial impact of increased retention.	Highlight data demonstrating impact of LA program on traditionally underserved students.	Connect 'wokening' faculty to on-and-off-campus colleagues who may legitimize scholarship in questions of equity and inclusion.

I hope this tiered structure models respect for participant autonomy and expertise, communicates a blame-de-emphasizing approach to the work of actualized equity and inclusion, and provides spiraled opportunities for LA-affiliated practitioners to both identify and discover themselves in the work as it feels applicable to them. If everything is, indeed, about loving and not loving, I may not approach this work with any perspective other than a loving one – for each and every stakeholder, and their gorgeous and true perspective, and their wisdom about the pace and direction in which they will stretch and grow.

Authenticity through Alternative Practicums: What Can be Known?

Mark Enfield, *Elon University*

Vexation

Throughout my career I have pondered the effects of practicum experiences on learning to teach. As a science educator who infrequently teaches courses with practicums, I am afforded many opportunities to reflect on students' learning from those experiences. I recently finished a sabbatical that involved STEM teaching as a participant-observer in formal and informal settings. Prior to that I also created and taught in informal STEM programs. My semi-detached role as a teacher educator coupled with my STEM teaching experiences offer me a perspective that provokes me to notice how school science often privileges memorizing vocabulary and formulaic approaches. In practicum settings, my students and I observe teachers relying on Pinterest-inspired lessons that use downloadable foldables, BrainPop videos, Kahoot quizzes, and transition from these 'learning experiences' using GoNoodle videos. I wonder 'where's the science?' As a science educator, I find these googled, cutesy, easily-reproduced activities do not advance understanding concepts and ideas and eliminate opportunities for inquiry or critical thinking. Moreover, they are only tangentially rooted in rigorous, well-developed curriculum, which reifies superficial "I can" statements that scarcely reflect the pedagogies we recommend. As a science teacher educator, I am concerned about how observing science taught this way impacts my prospective elementary teachers, implicitly suggesting that teachers must make their own curriculum based on the all-powerful googleverse.

> I acknowledge that this is an essentialized stereotype of teachers and STEM teaching, reflecting the most basic example. I have worked with outstanding STEM teachers; but they are rare. The issue is that my students observe a generalized experience that planning STEM learning involves fun, cute cookie-cutter activities from the internet and attention to ideas and understanding is limited.

During the spring of 2018, I was fortunate to teach an outstanding group of future teachers who struggled with me to dig deep into praxis and pedagogy, theories of teaching and learning, and striving to learn how to promote understanding. In class, we read, discussed, and watched videos, using those sources to consider approaches to utilize academic discourse to support children's learning and understanding. We considered the importance of experiential learning for children learning science. And we thought about the role of cognitive demand in developing deep conceptual understanding. However, when these bright, promising future teachers went to their practicum classrooms, they observed classroom teachers seemingly go through motions of completing premade worksheets, blithely assuming that if students filled in blanks on a worksheet this would yield deep conceptual understandings. I observed one teacher review all of Newton's Laws, doing a fantastic job helping students connect with the vocabulary, but never engaging students in first-hand investigations nor challenging students to apply those same laws of motion to real-life events, because, 'there is too much content and too little time.' My students' frustration came out in reflections that lamented that their teachers were not modeling or even open to teaching based on the research-based approaches we explored in our course.

> It is important to acknowledge that the practicum school had not provided placements for teacher education students for several years and was under scrutiny for performance on tests. I recognize a complex array of limitations. But I remain troubled by teaching that is so dissonant with research-based recommendations for effective practice.

Thus, my vexation, admittedly not a new one, is how do we have and/or create practicums that will support prospective teachers' development of pedagogies we believe are effective? In my state at this time, I do not think I can rely on traditional, public-school settings to provide such a practicum. Thus, I have created alternative practicums. Stepping back from this question, my vexation becomes broader. I wonder, given that I am not alone in this approach, has the field of science education arrived at satisfying conclusions about the impacts of alternative practicums? Finally, given that teacher education happens in a broad and diverse array of contexts, what empirical approaches and forms of evidence would allow us to make robust claims about alternatives to traditional practicum settings in science teacher education?

Venture

For several years I have experimented, though never thoroughly researched, alternative practicums for my teacher education students. My students have planned and taught: informal lessons at a hands-on science center, multi-week evening science programs, family science nights at schools, and week-long enrichment programs during public school holidays. Challenging teacher education students this way intended to resolve two problems. First, I wanted my preservice teachers to have opportunities to teach science. Typically, my students were lucky to teach one or two, text-based science vocabulary lessons in their placement classrooms.

Rarely would teachers allow hands-on investigations, full-on inquiry-based lessons, or allow much more than a 20-minute lesson or two. Second, my students would appear in a classroom, lead a lesson while the cooperating educator would manage students' behavior and most of the ill-defined tasks of teaching. Thus, I became concerned that the level of authenticity in traditional practicums is diminished by the structure of school and the norms already established by the classroom teacher.

This spring, I returned to a model of an alternative practicum that challenged my teacher education students to co-plan a week-long STEM enrichment program during the public-school spring break. Creating and leading a stand-alone program allowed for an experience that could be seen to its fulfillment. For this iteration, I added some features to frame my students' engagement. First, I was explicit about how we were going to work in a Professional Learning Community to co-plan the week-long program. Second, I made explicit the purpose for this approach and engaged them in thinking about the logistics, management plans, all the mundane, but often overlooked, teaching duties that are not included in teacher education. These steps invited them into the community of practice of educators that included thinking about what children should learn, how to facilitate that learning, and all the logistical details that go along with planning learning experiences. Third, I wanted to engage teacher education students in analyzing and using well-developed curriculum, in this case an Engineering is Elementary kit, to inform their planning and teaching. This was the beginning of my venture to engage students in actively applying learning.

When I read their reflexive papers about the week, my inference was that this was a powerful week for them. For example, students wrote:

> *"The lesson planning for the STEM camp required critical thinking, collaboration, and creativity and brought with it a multitude of growth and learning. When reflecting on the planning week, I can clearly understand my strengths and weaknesses related to lesson planning […and…] see the benefit in engaging in a professional learning community […]."*

> *"This week was an incredible learning experience that taught me a great deal about teaching beyond what traditional practicum experiences offer. First, the science week opened my eyes to the fact that much more goes into teaching than simply writing lesson plans. […] Prior to the science week, my field experiences have taken place in schools/classrooms where all procedures and logistics have already been outlined. Therefore, I had become used to following pre-existing routines without giving much thought into how they were established. In this case, we had to think about so much more than simply showing up for the school day; we had to organize the school day. "*

> *"As a group, we expressed our fears, supported one other with content that one of us might have felt weaker in, and took the lead when with parts that excited us. The positive professional learning community supported communication among our cohort and encouraged collaboration rather than competition."*

I think the students speak for themselves to reveal how this alternative practicum created opportunities for them to authentically engage and learn from their experiences. This success encouraged me to begin thinking about communicating with the broader science education community. Yet I also recognize that this is an idiosyncratic situation that may not be replicable elsewhere and more importantly do these outcomes lack reliability (I had a fantastic group of teacher education students).

My venture now launches from this idea and experience. I want to begin to think about meaningful, substantive research on alternative practicums. This raises a few questions:

1. What kinds of evidence will be compelling about the impact of alternative practicums in science teacher education?
2. What approaches to inquiry would be productive (e.g. quantitative studies, meta-analysis, etc.)?
3. How would I build a community of scholars engaged in similar work and how would we being to collaborate across contexts to develop richer, more meaningful understandings about alternative practicums?

My venture is to begin pursuing these questions at Crossroads and with the extended community of Crossroads to investigate this approach and understand what is meaningful, effective, and productive in alternative practicums.

Stepping Into Policy & Advocacy

Rachael Gabriel, *University of Connecticut*

Vexation

They're coming for us. With pitchforks. And Phonics worksheets. This past year a parent advocacy group found more than 14 sponsors for legislation that would require all faculty who teach beginning reading courses to take a phonics knowledge test (or course and then a test) in order to be recertified by the International Dyslexia Association (IDA) to be allowed to teach their courses. It would have required all teacher preparation programs to become accredited by the IDA in addition to or instead of whatever other professional organization. Finally, it would have required all preservice elementary school teachers to take an additional licensing exam focused on dyslexia, at an additional individual cost, even though they already have to pay for a reading-specific state licensing exam in addition to the regular praxis series. This is the latest in a six-year run of legislative hearings related to bills raised by dyslexia-focused parent advocacy group with parent-led chapters in every state. But, it is the first time these efforts have targeted higher education rather than only pre-service or practicing teachers.

Reading is always in the news and on the policy agenda. As a reading teacher and reading education professor I orient to policy as both an advocate and a critic - studying the unintended consequences of reading-related policies, and working to inform policy conversations by generating and disseminating research evidence. Lately, however, I am finding my relationships to policies are changing as I become not only a critic and informant but a target of policy efforts.

Five years ago, the policy priorities of paralleled existing policies related to reading difficulties in general (more assessment, remediation and teacher training), and focused primarily on elementary schools. The first few bills were pretty transparent money makers because they required districts to choose from a short menu of state-approved commercial assessment and curriculum packages and to contract with particular for-profit providers if they didn't have certain elements in place. I worked with schools and districts to understand and responsibly respond to the mandates in new dyslexia laws, with varying degrees of success. I am now working within our teacher preparation program to do the same. Yet, the latest newsletter from the IDA features an article explaining to parents and advocates that:

> "Children are the casualties when the science of reading is not used to teach reading acquisition. Faculty in colleges of education with insufficient training in science and research methods do not possess the skills necessary to read, understand, and critically evaluate the components of the science of reading, which leaves them susceptible to using (and teaching) strategies that are not valid."

Meanwhile, the "science" they advocate, programs that use Orton-Gillingham methods, have a mixed research record in peer-reviewed analyses and meta-analyses, but a number of commercial publishers and for-profit organizations have successfully marketed these to parents and schools through private providers and consultants. Here again the money-making motivations seem pretty transparent, but it now comes paired with distrust and disdain for public schools, teacher educators, and anyone who espouses a different understanding of the "science" of reading.

Dyslexia advocacy efforts now touch, trigger and parallel lots of other issues like the transition from accountability to privatization policies, privileging evidence from neuroscience and psychology over evidence from social science and sociology, conservative vs. liberal ideologies, visible vs. invisible pedagogies, what counts as the science of/scientific reading and research and the academic freedom of professors at state-funded universities. It's fascinating, but it's also fraught with professional danger for someone who works at a state institution at the intersection of literacy and policy, and often in partnership with public schools. My research focuses on the discourses of local, state and federal policies that relate to reading instruction and intervention. I teach in a program that prepares reading specialists, which includes directing a clinic where I supervise specialists who assess and teach students with reading difficulties. I also consult with districts on RTI/MTSS systems and individual cases of students with contested IEPs and diagnoses. So I wonder:

1. How do I generate, disseminate or translate research in ways that supports teachers, students and parents in an increasingly polarized conversation about reading difficulty? Where could it go? What forms could it take?
2. How do I generate, disseminate or translate evidence within advocacy discourses that show increasing disdain for the social sciences and a hierarchy of disciplines that puts education beneath psychology and neuroscience.
3. How do I balance reaching out to learn from people I disagree with, without wasting time being humble about what I know?
4. What can I learn from previous (ongoing?) attacks on teacher education or higher education in general that could inform how I position myself now that I am the target of policy rather than the informant or critic? Can I be all three?

Venture

So far I have attempted three ventures, but I believe they are inadequate and will become irrelevant as I work to publish more direct critiques, and as advocacy efforts turn the public against education researchers and public school people like me.

1. I've worked with a handful of schools and organizations to understand how their work can align with state law without abandoning research-based approaches recognized by IES and the US Department of Education. These are all high-performing, well-resourced districts that reach out to me because they want to protect their ways of doing things (well) - but what about all the others?
2. I've analyzed the policymaking process and how language is used to frame dyslexia as a policy issue with a policy narrative that privileges private providers over public schools. Every time I present this work an audience member (usually a parent) cries. It is just beginning to come out in print.
3. I've created public forums for discussion with invited speakers who attract audience members from all sides of the issue. These events only reach a few people (~40), but have led to sit-down conversations with advocates who refer to me as "the enemy" which have taught me a lot about tensions and assumptions I never knew existed.

There's more to learn, but there's also so much to be done, so where do I start? I'm not sure whether to focus my efforts in schools, among advocates, on policy or within teacher preparation, but I know work in each arena is slowed because my attention is split between them without strategy. I'm not sure whether to zoom out and view all this as battles of science and evidence with an invitation to rethink how information about reading/reading difficulty is presented to teachers and parents, or to zoom in and analyze the political choreography of the dyslexia advocacy agenda as a case of privatization in response to the excesses of the accountability movement.

Though I have studied, presented and published about the written testimony associated with recent legislation, this past semester I found myself submitting my own written testimony. I don't know how to do this without seeming like a defensive teacher educator trying to rationalize my existence. But I also can't sit and watch people arguing for policies I believe unnecessarily blame teachers, limit important work, and advance narratives whose endpoints are the privatization of education services for students with certain disabilities, but not others. I think this limits parents' (and therefore students') options, and could somehow hijack the academic freedom we value so much in higher education. The higher ed bill did not pass in the most recent legislative session, but similar legislation passed in some states, and recent trends suggest that this group will try again with a revised bill next year. I know I won't be able to resolve the many tensions that led to this place in reading, education and policy more broadly, but given the implications, I would like to have a clearer, slow-and-steady path forward.

Wonder and the emotional domain: Living up to the mystique of science

Andrew Gilbert, George Mason *University*

From the moment I could talk, I was ordered to listen… - Cat Stevens

Vexation

Psychologist Ellen Langer (1975) articulated the “illusion of control” where humans often feel they can control and influence outcomes for which they truly have no power altering. Jen Gilbert (2014) touches upon how this illusion infects teachers who desperately try to control students because they fear the wildness of children and the limitless complexity for the adults they will become. In terms of science, elementary teachers often fear science content, which I argue is not because of the difficulty of content, but rather they fear the unbounded possibilities that unrestrained thinking might bring to the classroom. Children whose thinking challenges the “authority” or the “knowledge” of adults, represents a particular strain of wildness…a thinking child who refuses to tame their imagination. Scientists embrace and celebrate this type of thinking in the mystique of science. Consider the musings and contestations of Neil Degrasse-Tyson reminding us that children are born scientists and we just need to get out of their way. Richard Feynman similarly suggested, “Study hard what interests you the most in the most undisciplined, irreverent and original manner possible” (Feynman, 2005, p.206). Teachers and schools rarely share this enthusiastic view of the untamed child rather the child is something to be controlled including their movements, thoughts and particularly their emotions. Children are reminded that their thoughts typically only have value if the fall within the tightly bound confines of state-mandated curriculum goals and testing measures. They are reminded through the near constant admonitions to lower their voices, always raise your hand, only speak when called on, no talking to peers, etc. and these are policed with threats and punishments including isolation, losing outdoor time, and other privileges. An unfortunate byproduct is that joy, pleasure, independence, stubbornness, risk-taking, questioning, puzzlement, awe, and “irreverent” solutions are not valued as key elements in their future scientific selves. In order to counteract these issues I have turned to teaching frameworks steeped in wonder to rekindle future teachers emotive connections to science, but more importantly to facilitate teachers with becoming accustomed to the uneasiness of not knowing. The goal is to facilitate their vision of children’s unbounded thinking (as well as their own) as something to celebrate not something to fear.

Wonder places human experience and observations of the natural world at the center of the inquiry process, which forges a pedagogy that demands connection to the emotive embodiment of science and is a uniquely human process that nurtures our intense need to know (Gilbert and Byers, 2017). This is a direct effort to evoke emotion, which runs counter to most elementary classrooms. Over the last several years, I have developed many approaches that work to bring wonder and wonder-infused pedagogy to life in my teaching including: wonder lists, wonder journals, wonder projects and approaching science and the natural world through a mindset steeped in wonder. These include readings regarding research in wonder as well as scientists describing the role of wonder in their work. We work on noticing and sketching through a series of outdoor observations, which become a means to build their journaling skills. These then become the basis for the end of semester “wonder project” where they choose one entry and delve deeply into the science related ideas, content and issues associated with that wonder and we hold a final “wonder project” reception during the final class displaying our findings.

This leads to a series of vexations: 1) How do I support pre-service teachers in taking risks toward wondrous thinking given their propensity to focus solely on grades? 2) As a teacher educator, how do I assess the value of a pre-service teacher wonders and their engagement in terms of science content? 3) As a researcher, what types of measures would help to elevate wonder and wonder-infused pedagogy toward a viable research approach? These vexations rise from multiple avenues, but continually students and reviewers have requested more insights and clarity for these questions. I do not have simple answers, but the following highlights how I am trying to move forward in both of these areas. As a teacher and a researcher, I am haunted by the words of a former student, “Wonder is kinda like love, if you try and understand it too much, it ceases to be special.”

Venture

Pedagogical venture

The first solution is to simply accept that building wondrous connections to science is not easily quantified and continue my practice of giving complete assignments full credit. However, the reflective practitioner in me keeps pushing both my own understanding for how to best meet the needs of students. In terms of journal assignments, there is much hand wringing and worries from students because they want to know exactly how to proceed. In an effort to assuage their worries and provide some guidance I have developed an optional journal format. The goal is to simultaneously remind them that their thoughts, ideas and wonders are valuable, while also guiding them to consider the science involved in those thoughts. The following journal prompt works to do this:

1) Give some general insights into your wonder - Where did it arise? What about it interests you?
2) What are some of your hypotheses for why this phenomenon may exist? What prior knowledge might be helpful to consider? What might you need to know more about?
3) Could you design an experiment to learn more about your wonder? What research tools might help?
4) If you desire to 'Google it'…wait 24 hours and let your thinking percolate…then provide any insights your internet search provided. What new questions do you have?

Again, this is an optional format and students are free to ignore it. This is an attempt to structure experience so that students envision the direct connections between wonder and science. These journal entries and format become the currency for their final wonder projects that delve deeply into a chosen wonder and create a public presentation to share with the group. This fall, I will attempt to work with my GA and my science methods students to develop a method of scoring the final projects that honors student experience, science and the process of wondering.

Research venture

Currently, I am working to develop a 'science wonder' framework that comprises the theoretical components of wonder and how those impact our affective, emotive and personal conceptions of science. The goal is to consider science as a means of inquiry, but one that is driven by a human desire to know the world in which we live, breath, work and play. Van umm, Verhoeff and Peeters (2016) articulated four domains of science education: conceptual, epistemic, social and procedural as part of their framework for inquiry. I argue for the existence of a fifth domain in science education, an emotional domain.

Wonder itself becomes the entry point into the emotional domain, which directly feeds a desire to engage in scientific thinking. Scientists have described this emotional connection over the years as they rejoice in the mystique, beauty and inspiration that science provides them. The key is that science educators rarely try to intentionally tap into this conduit that feeds scientific desire. I have compiled findings that shed light on the emotional components at play through wonder and how those components impacted a desire to learn about scientific phenomena as well as a means for students to experience the mystique of science for themselves. The components of the emotional domain accessed through wonder include: desire, vulnerability/trust, joy, imagination, sacred nature of thoughts, and an acceptance/awareness of complexity. The components are still in development, but offer both interesting possibilities and obvious challenges in terms of research.

Some questions I would like participants to consider:

- Is it possible to build a framework for the emotional domain in relation to wonder and not lose the element of undomesticated thinking that makes it so special?
- Would it be possible to build meaningful instruments for such a framework?
- How might I best capture the evidence of these emotional connections to wonder and wondering that have viability with journals, editors and funding institutions?
- How do I push boundaries in a field that espouses wonder in its mythology, but not necessarily in its practices?

Challenges to the Identity of African American Men while Working in Predominantly White Environments in STEM

André Green, *University of South Alabama*

Vexation

The assimilation of African American men into STEM fields remain a major concern for me. Racial inequality and prejudices are major contributors to this worry in that they perpetuate the marginality of the African American male, as well as the African American community (Franklin & Franklin, 2000). Tatum (1997) defines this marginalization in her book "Why are all the Black Kids Sitting Together in the Cafeteria" as "the cultural images and messages that affirm the assumed superiority of Whites and the assumed inferiority of people of color." These messages, embedded within the subconscious of the whole of society including African American males, play a major role in determining their status in the social order. What happens to a system like STEM, when individuals it was designed to keep out are now able to enter. Further, how does that system impact the functions of the intruder — the African American Male?

Over the course of United States history, Whites (the dominant group) have continually held positions of power and wealth over other minority groups and over time, this way of life has seemingly been preserved for future generations. This preservation suggests that a system is in place to maintain the status quo creating an advantage for the majority. This system of advantage as described by Harrell (2000, p. 43) is:

> **A system of dominance, power, and privilege based on racial group designations; rooted in the historical oppression of a group defined or perceived by dominant- group members as inferior, deviant, or undesirable; and occurring in circumstances where members of the dominant group create or accept their societal privilege by maintaining structures, ideology, values, and behavior that have the intent or effect of leaving non-dominant group members relatively excluded from power, esteem, status, and/or equal access to societal resources.**

Tatum (1997) described this system as "not only a personal ideology based on racial prejudice, but a system involving cultural messages and institutional policies and practices as well as the beliefs and actions of individuals" (p.7). She further notes that "in the context of the United States, this system clearly operates to the advantage of Whites and to the disadvantage of people of color" (p.7).

This system described is a reality of many African American men and these experiences have conscious and unconscious impact on their lives. The system of privilege that the dominant group enjoy in many instances oppresses and denies African Americans and other minorities those unalienable rights that the fathers of the constitution guaranteed.

The system of advantage depends heavily on the ability of the dominate group to keep those who are considered subordinates out of certain arenas. Those in power set the parameters in which those without power operate, therefore those who have power have a large amount of control in shaping the structure of society. As it now stands, the structure of society has African Americans, and especially African American males, at a disadvantage because, in general, the dominant group has predetermined their position. That position is typically one that has devalued significance because in the usual course of events African American males, in general, have been considered through-out history as less than and incapable of contributing anything of importance to society.

Typically, when many African American males strive for a higher level of achievement they enter "subcultures representing images and ideas that may exclude or discourage their participation" (Brand, Glasson, Green, 2006, p. 228). When African American men become educated, articulate, and focused they are rejecting the negative portrayal and the predetermined and devalued positions that society has seemingly reserved for them. As a result, African American men who strive for a higher level of attainment both professionally and educationally enter spaces that have primarily been reserved for those that the system of privilege was designed to benefit.

Challenges to the Identity of African American Men while Working in Predominantly White Environments in STEM

André Green, *University of South Alabama*

In predominantly White environments many African American males look and may feel like outsiders because few people, in these environment, resemble their physical characteristics. Looking at this situation through the lens of race only, this lack is a problem because from the onset they are at a disadvantage since they have no one with whom they can identify racially. Participating in a predominantly White environment for African American men (or women) has the tendency to cause: (1) apprehension about abilities; (2) an on guardedness toward the environment and toward individuals in that environment, and; (3) a lack of trust for co-workers for fear of being betrayed in some way. Being in the majority is an advantage simply because people in the environment are connected in terms of their race (Burt, 2004). Those in the majority simply do not have to worry about any of the three characteristics mentioned above as it pertains to race, meaning the person may have doubt but that doubt is not a result of being African American.

Many educational and professional fields or high positions within any field have stereotypes that seem to define it and those stereotypes have been reinforced for years. Those stereotypes dictate that white males are the major participants and are in control. How these fields are studied and controlled are all factors that contribute to the stabilization and perpetuation of a singular image of who has the majority access to it. STEM fields are perfect examples of this phenomena.

My vexation, or the question that I want to answer or explore, is what happens to African American males who assume positions socially considered beyond their capacity or was not historically designed for them? What challenges do they face from external forces? What are they feeling and how do they cope?

As an African American male I know how feel and I often wonder why I feel this way. I feel at times like I'm trespassing into spaces that were not designed for me. Feeling this way lead me to look up the definition of a few words. Trespass, encroach, infringe, intrude as defined by dictionary.com implies overstepping boundaries and assuming possession of others' property or crowding onto the right of others. To trespass is to pass unlawfully within the boundaries of another's property. To encroach is to creep, gradually and often stealthily, upon territory, rights, or privileges, so that a footing is imperceptibly established. To infringe is to break in upon or invade rights, customs, or the like, by violating or disregarding them. To intrude is to thrust oneself into the presence of a person or into places or circumstances where one is not welcome… This is literally how I feel at times and I often wonder if others describe it in the way that I do. I wonder: how does the young African American male feel in science class. I wonder about the African American male working in a STEM field where there are typically not many people who look like him. I wonder how the African American in STEM feels as one of a few (if he is lucky) on a predominantly white campus.

Venture

My next step in this process would be to interview, poll, or survey different African males in different arenas in science education. I would want to chat with middle and high school students, college STEM majors, those in graduate school, and those who work in the professional arena (industry or higher ed). I would like to map it out to see if it is a similar as I think regardless of the arena.

My thoughts have not gone too much beyond the above. And I know that a person's experiences cannot be dismissed every time they enter different phases of their lives. Experiences inform other experiences. A person's race, ethnicity, culture, religion, upbringing, etc. influences his/her life. Perceptions are swayed by their past experiences and often the behaviors people demonstrate, and the underlying foundation behind their actions, can be linked to past experiences. In socio-cultural theory, a person cannot separate out phases of life since every aspect of life is intertwined with the other. For example, a child attending school does not enter that school void of life experiences. Those experiences frame the way that child views education, the teacher, the school, etc., because those experiences are a part of the child, they are inseparable. How does this play out in African American men who are in STEM?

Real World for Real People: How to systematically change large organizational systems and culture with a small army

Tyson Grover, *STEM Director for Davis School District*

Vexation

I recently became the STEM director for Davis School District. Yes, I know that title screams many things at all of us which we can talk about over our three days in the mountains and it is the reason for my vexation, but it will ultimately also be how I move forward with my venture. My small STEM army consists of six dedicated and passionate educators/administrators. They all have their distinct areas of support such as K-6 mathematics or K-6 coding and computer sciences. We cover an immense number of students and a wide diversity of teachers. Under my umbrella of support there are approximately 80,000 students, 2000 teachers, and about 300 administrators. We have sixteen Title-1 schools that are part of the 62 elementary schools supporting our K-6 students. We also have seventeen Jr high schools that run 7th to 9th grade, and ten high Schools supporting 10-12th grades.

If you look at Davis from the numbers and data on the web it seems to be a low diversity affluent conservative area. However, my years in the district have shown me each of these schools are very different in culture, needs, community, and especially their problems. We are continuing to grow every year and are projected to build more jr high schools and more elementary schools in the next five years. Just to keep the Davis School District train moving is a feat that surprises me every day, because we do it and do it well.

With the move to my new position I have started to think about the span of influence I might have and the dreams I might be able to accomplish. The biggest of these is finding itself rooted in the separation of content areas over time by the school system taking away from the context of learning and real life. Language arts, mathematics, science, social studies, the arts, and healthy lifestyles all cut into their perfect time slots and separated from one another so concretely that students no longer understand they are all part of the answer and they all have context in the real world.

We don't want to groom students to be language arts specialists or people who only see the world scientifically. We want a system that focuses on wonder, sense making, problem solving, collaboration, and growth of the entire human. For so long school has been segregated. It's gotten to the point some may think developing humans who can think, love, create, collaborate, and see the world from a variety of lenses is not our job. Teachers laser focus into their curriculum and standards and forget the rest of the world exists outside their classrooms. Then we take it a step further and we do this same thing at the higher ed level and produce science education graduates who also see science as separate from everything else. On the flip side there are schools like Weber State who are putting out amazing new teachers focused on the right things but they are being dropped into a system that does not support what I outlined above.

As a previous science educator, I would say our job is to teach these kids how to make sense of the world, understand what science is, how scientists work, and so on but it cannot be presented as separate. The world is all around us and it needs to be explored, questioned, wondered about, admired, and analyzed. So what structures in our organization need to change, what needs to happen to change this deep-rooted culture of segregation of thinking, and how does my little army start this journey? `

The vexation in my new position is that I do not feel like we can continue in this path. Disruption must take hold and the system needs to be broken. Where do you start? Schools are basically the same as they were fifty years ago, but society and how we interreact with the world has changed on an unimaginable scale. What needs to happen in our schools at a systemic district wide level to meet the needs of those 80,000 very different individuals and very different communities? Do subjects need to be given context outside of class or are subject specific classes ok the way they are? Is it as simple as focusing on what we do in the physics class that matters? This is where I find myself. Staring five years into the future wondering what it will be like and how can I work with a 9th grader today so they are working on being ready to actively participate in that society. What needs to change in our scheduling, teaching, collaboration, and curriculum to prepare students for a world that we have no clue what it will look like? One thing is for sure and that is our current system will not work.

Venture

With this new role I now have the influence to affect what happens in STEM subject areas along with how they integrate with all the others. Personally, I am not a fan of the word STEM simply because it once again segregates the subject areas instead of pulling them together. So, how will we address this issue of relevance and context in school. For science it seems we are getting closer by engaging students with phenomenon, and creating a student-centered teacher-directed classroom where students are actively engaged in the practices to wonder about the world, make sense of it using practices, and solve complex problems. How do we bring it all together on an ongoing basis?

My team has brainstormed and argued over and over on where to start. Do we focus on curriculum, teachers, organizational systems, or standard frameworks? I would argue none of those are where to start and that the actual starting place changes nothing other than mindsets. Organizational systems won't change until there is support from the masses. The masses won't change until they see the why. Once the why is established they will define the standards. Curriculum will follow from there.

We originally got ahead of ourselves and thought if we start at the curriculum level and establish a road map for teachers that integrates across curriculum areas we could start teachers on the path. We also thought this would be a solution to the vast numbers of classrooms we hope to affect. The life of a teacher in our current climate is not sustainable. The reality is if the masses of teachers don't have a foundation to use in the teaching model we want to see then they have a difficult time making the shift. They have so many things added to their job duties that when the time to innovate comes they revert to the old ways. They have become survivalists.

So, the plan was to have the team start by sequencing and mapping out all of the core ideas for science, math, language arts, and social studies. Once this mapping was complete we would do an analysis of the core ideas and come up with what is essential to the students. What do they really need to know and do. Once this had been mapped we would make modules centered around some real-world problem, event, issue, or phenomenon. Keeping the focus on students engaging in performances using the practices. Our team sees the science/engineering, math, and language arts practices as the key to pulling this all together. As we started this we realized this would be a waste of time with the current culture.

The curriculum can be created but won't be used by the masses without the underlying culture of changing why we go to school each day. This skipping ahead is where things fell apart in our planning. We took this same curriculum development approach with the move towards three-dimensional learning in science over the last four years and we have seen large scale movement in teacher practice. The level of three-dimensional learning taking place is a beautiful thing. The difference was with three-dimensional learning we took the long road starting with grassroots development of the why behind wonder, sense making, and problem solving. The focus was not on "The 3Ds" or "Integration" or "STEM" but instead on the student as a human and why they should wonder, make sense of things, and problem solve.

We are starting over with open minds and are moving towards starting with focused conversations with teachers, administrators, and communities about where education is going and what we value. Planting seeds to grow the culture moving forward. We want these conversations much like this conference to look at the problems, spotlight pockets of innovation, and come up with new ideas to move forward. The changes we want to see will take place at so many levels and my team is prepared to monitor and respond. We will need to be watching our organization, our communities, schools, classrooms, and our students in order to respond when needed to move the culture forward. Eventually we will get to frameworks, standards, and curriculum; or maybe we won't if it is not shown to add value in moving the culture forward.

The hard truth is that school is falling behind the real world and is losing context. I want my own kids to go to a school that when they come home they are passionate about the work they are doing because they own it and it has meaning. Right now, they can barely remember what they did each day and when asked what happened at school they just say it was the same old thing again. How do we create a system where kids are engaged, that has real relevance to students, and how do I create a foundation that can work for 80,000 students at 88 schools?

Seeking Authentic Engineering Teaching Methods for K-12 Science Teacher Education

Amanda Gunning, *Mercy College*

Vexation

Since the *Framework* and the subsequent arrival of the NGSS, I have been intrigued with preparing K-12 teachers of science to not only address scientific practices in their instruction, but also to include engineering, as one would expect. But the how of doing this has long vexed me. The issue is something I find some teacher educators take for granted, as believers in the NGSS, colleagues march forward, sharing and preparing in the best ways, in their skill set. However, as concerned educators, what actually IS the best way forward? How can we truly give in-service and pre-service teachers a rigorous preparation in engineering when so few science teacher educators actually have engineering experiences?

I feel uniquely situated to bring up this issue. As a former physics teacher, I worked closely with the tech ed department and did interdisciplinary units between the physics and engineering classrooms. I participated in an NSF RET in electrical and mechanical engineering and have developed colleagues in the field of engineering that cringe at some of my 'best practices.' They look at what we do using pipe cleaners and paper towel tubes as inauthentic at worst and 'engineering lite' at best. Their systems thinking approaches and technology far outstrip what is accessible to most teachers in most classrooms. How do we reconcile engineers' preparation and work with our K-12 science teacher preparation? Do we need to?

Tonso and Weinstein have been critical of engineering's inclusion in science, citing its misplacement in the standards: "teachers are forced to spend time on what the standards argue is engineering practice," which they dub 'school-engineering' (2014). Instead, I believe and champion engineering's inclusion, even if it is imperfect. Tate's (2001) seminal work explained how the fight for equity in schools has moved from the area of space and desegregation to quality STEM education and access to high-quality resources and has been further developed, couched in the urban setting (Riley, 2008; Baillie, Pawley & Riley, 2012; Tate, Jones, Thorne-Wallington & Hogrebe 2012). I firmly believe that all students need a firm science AND STEM foundation to be literate members of society who have an idea of the full array of job and career opportunities that the world presents. The Science and Engineering Practices push students to think critically and productively in ways authentically connected to our world. They also expose students of all ages to the idea of engineering and the career possibilities that may exist. But some research shows that K-12 teachers of science exhibit anxiety towards including engineering and have little understanding or experience with engineering design (Hsu, Cardella, & Purzer, 2010; Katehi, Pearson, & Feder, 2009). And developing comfort levels with implementation is still being understood (Cejka, 2005; Cejka & Rogers, 2005; Robinson & Maddux, 1999). Teacher content knowledge and familiarity with subjects are directly related to how much they teach topics and the ways in which they teach them. A lack of understanding of and familiarity with engineering content and practices suggests that teachers will not effectively teach engineering content in their classrooms (Jones & Carter, 2007; Katehi, et al., 2009). While I teach K-12 pre-service students engineering design and engage them in several engineering activities in the methods courses, I find when observing these same students during their clinical experience, very few actually employ engineering activities and principles in the classroom. I have been telling myself, 'It is too early, they are just learning' or 'when they have their own classroom they will do it' – but I am not sure they will. I see them implement hallmarks of good science teaching in their placements, so I ask, why not this approach?

Cunningham and Kelly (2017) lay out epistemic practices in engineering as path forward but how can teacher educators start implementing this work in the field? It is one thing to present the engineering design cycle, a whole other world to attempt to impart authentic knowledge of how engineers solve problems through practice. Each semester brings a wave of fresh-faced teachers we want to prepare in the best ways possible. Similarly, each foray to develop and support practicing teachers is an opportunity to make gains in science and engineering education, but what would the most productive approaches be?

Questions

1. Which experiences are most beneficial in resulting in teachers developing authentic understandings of the work engineers do?

2. Is it possible to provide these experiences within the constraints of an ordinary/existing pre-service program?
3. Is it important to do so, or is 'engineering lite' sufficient?

Venture

For my first venture into this field, I conducted an exploratory study with colleagues with pre-service secondary teachers using a self-efficacy framework (Gunning, Marrero & Riccio, 2014). While this approach was successful in bolstering our students' self-efficacy for teaching engineering practices, it is unclear if there remained any lasting impact on their future practice. (I am now thinking I need to reach out to those teachers again!) Another venture I have undertaken is through an NSF-funded partnership with a well-respected engineering school. Through a Track 1 Noyce grant, I have studied pre-service teachers in a week-long engineering and robotics course, again I employed the framework of self-efficacy (Gunning, Riccio & Marrero, 2018). While some gains were made, largely the intervention has been ineffective.

The latest venture that lies ahead is the creation of a graduate course for in-service and preservice teachers that leads to an advanced STEM teaching certificate. I am fortunate that I recently garnered a NSF Noyce Master Teacher Fellowship grant to support 14 K-12 teachers of math and science to become STEM master teachers. This is exciting because these teachers, who must already be considered master teachers by their districts, are experienced and were trained before my state adopted its version of the NGSS. My program will provide an opportunity for the fellows to take STEM pedagogy courses that are part of the certificate. Specifically, the course *Engineering for the K-12 Classroom* is described as: *Teachers will become proficient implementing the engineering design cycle and Science and Engineering Practices, as outlined by the NGSS. Teachers will learn how to apply engineering practices to integrated projects for K-12 students, while raising awareness of careers and innovations in engineering. Students will demonstrate an understanding of the history of engineering and its impact and shaping of society in the United States and globally.* I created this course and am set to teach it next fall. But my vexation remains – I do not know if it will be successful. Although I am not a trained engineer, I understand that an engineering mindset is not easily acquired, and Tonso and Weinstein's voices whisper in the back of my head that the best I could possibly do is only engineering-lite anyway. I am thinking hard about how to construct the learning activities to engender the approach engineers may take and to demonstrate the process to my teachers. But after that concern, what follows it quickly is if the teachers will be able to successfully integrate these methods into their teaching as part of their go-to skill set. I fear they regard it as an engaging approach to be implemented once or twice a year, instead of mindset change. I worry that my best intentions will fall flat, in terms of students' ability to employ the engineering practices in their own classrooms. I am not sure the best way to explore these concerns and study the course at the same time.

I am fortunate, through this Noyce grant, I have set up a professional learning community (PLC) to help support the course creation and implementation. Part of this PLC is an engineering professor, but I am honestly curious how we will be able to find common ground. Although he has organized countless professional development sessions for NYC teachers, his research on the work he has done with teachers and his general mindset approach to engineering is at the complete opposite the engineering approaches we see and read about in science education circles. He also sees this as engineering-lite. For me, this is another indication of the vast divide science teacher educators must cross to begin to approach adequate science and engineering practices instruction for teachers.

One more fortunate piece related to this grant is that I will be able to follow the teachers for four years after they take the *Engineering for the K-12 Classroom* course. I want to discuss with you all how best to utilize the opportunity to follow these teachers and learn about their development or non-development of the ability to successfully integrate engineering practices to their instruction. I would love to provide for the field with research-based ideas about how preservice programs could better prepare teachers.

Quantifying Qualitative Data: Building a Bridge to Understand Capacity for Teacher Change

Kathryn Hayes, *California State University, East Bay*

Vexation

I have been thinking a lot about research methods lately. In this vexation, I will briefly summarize one of my problems of research, and discuss why I think it needs a new methodological approach. In the venture section, I will lay out what I have thought about and tried. I welcome your insights. Much of my research is guided by the following broad question: What aspects of organizational capacity are necessary to facilitate teacher change toward student-centered, equitable science teaching? This question, if not causal, is at least explanatory. That is, I am interested in the relationships between aspects of capacity—anything from teacher knowledge to organizational climate—and instructional reform. Such a research question, in the minds of many researchers, would require measuring a variety of elements of capacity and analyzing the quantitative relationship between these and instructional practice.

Herein lies the vexation. On one hand, elements of capacity are very difficult to measure quantitatively. Some measures do exist—for social capital and organizational climate, for example (e.g., Leanna & Pil, 2006; John Settlage has also been working on this), but other aspects of capacity are difficult to measure, such as the degree of hierarchy and centralization in the district (e.g., Datnow & Stringfield, 2000). On the other hand, typical qualitative methods often lack the comparative power to address the research question. Comparing across contexts with a qualitative analysis can be boggy territory. Yet because I think people in the business of instructional reform (policy makers, PD providers, science at the crossroaders) need tools that work in a variety of contexts, understanding how capacity works across contexts is important. For example, research could establish elements of capacity that tend to work across contexts (e.g., relationships matter) and those that tend to differ by context (e.g., in high poverty contexts teacher change tends to be interrupted by fragmented policies).

Venture

So how do I build a bridge across this boggy territory? In their chapters on causality and explanation, Miles and Huberman (1994) propose a series of qualitative analysis steps which include determining the timeline of events or processes and relationships across elements, resulting in an explanatory model. If Miles and Huberman (1994) are right, you can draw a general picture of the processes that lead to a particular outcome (instructional reform). But what if I wanted to know the degree of leverage of each element of capacity? In the following paragraphs, I lay out an example of my research, how I am trying to address this vexation, and my remaining questions.

In order to illustrate the issue, I will focus on one case study, San Isabella district. The goal for analysis was to document the elements of capacity indicated by participants as developing or eroding opportunities for science instructional reform. First, in an iterative process between coding and reviewing the literature, we built a framework consisting of the key elements of capacity that supported or eroded the reform process (Hayes, et al., in review). These elements of capacity were organized at the individual, organizational, and external levels, and included five dimensions (expertise, cultural, social, structural, and policy). Overall there were 12 elements of capacity.

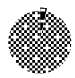
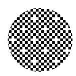
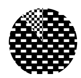
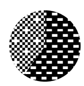
Concurrently, we collected 15 interviews of teachers, principals, and district administrators. As we coded the interviews, we used a deductive framework based on the Instructional Capacity Framework. We allowed specific resources within the 12 elements to emerge (Miles & Huberman, 1994). For example, we pre-set the category of organizational structures, but we allowed specific structures to emerge from the data. The following example excerpt illustrates the coding process. A principal was describing efforts to establish professional collaboration time for science teachers across schools:

> Last year the science teachers said, let's have four days so we can all meet…What [teachers] wanted was time to collaborate…So [another principal] and I were really good friends, so we said science needs this, it makes sense, and then we all went back and sold it to our sites.

At the individual level the codes included Expertise: leadership skill. The codes at the organizational level included Cultural dimension: teacher agency; Social dimension: relationships between administrators, political capital; Structural dimension: schedule alignment and PLC opportunity.

The resultant data set can be interpreted qualitatively, as general patterns. However, to document the influence of each resource, we counted excerpts or cases, as has been done in pockets of literature (e.g., Brown & Crippen, 2016; Coburn & Woufin, 2012). Examples from our case study show how counting might allow for comparing different types of resources for facilitating or impeding science instructional reform (Table 1).

Table 1. Emergent resources under organizational structures. Pie chart indicates extent to which resource supports (lighter grey) or undermine (darker grey) instructional reform.

Specific resource	# Text Segments	Extent supports	Description
Professional learning opportunities	117		Opportunities, support, or time for professional development, lesson study or Professional Learning Communities.
Scheduling	41		The state and nature of district and school schedules, often regarding alignment of professional collaboration time.
Math-science coring	38		The situation in which individual teachers teach both math and science for a “cored” group of students.
Curriculum and assessments	22		Text, pacing guides, assessments, curriculum tools. (Negative was primarily related to frustration with texts and pacing guides.)

These counts provide a way to answer the questions I’m interested in regarding which resources play a pivotal role in supporting teacher change. But are they valid enough for a numerical comparison? I hope the validity vexations and ventures described in Table 2 will serve as a foundation for our conversation during crossroads.

Table 2. Potential issues with validity in counting and comparing excerpts, and ways they may (or may not) be ameliorated

Vexation	Venture: Ways I tried to ameliorate issue
Interviews: The interviews themselves could be skewed. For example, I could have asked many more probing questions about structural elements than expertise.	Interviews are conversations. They are always going to be skewed in some ways. However, asking the same general questions and then probing the extent of the participants thinking and experience in each area should provide a relatively balanced idea of what they consider important.
Excerpts: The bounding of excerpts would have an influence on the numbers in any given area. Someone could talk at length about shared leadership, and the transcript could be divided into 10 excerpts on shared leadership or treated as one instance.	The bounds of the excerpt should be set by the start and finish of conversation regarding one resource, so that if a participant talks a long time about one, it does not result in more excerpts. But…if a participant talks a long time about one, doesn’t that mean it’s more important to them?
Comparing across contexts: Ultimately, I would like to be able to compare the way capacity works between low- and high-income contexts. But here again the role of sampling and interview focus become problematic.	If I carefully conduct my interview sampling (i.e., the director at each district, every teacher leader, etc.) and follow protocols, the data may be comparable.

So my dear colleagues, here is the vexation and venture in a nutshell: I believe that establishing excellent, equitable science instruction, especially in schools that serve marginalized youth, requires a thoughtful approach to district and site capacity. There is a need for much greater understanding regarding where to target scarce resources to build this capacity. This begets an educational problem that would benefit from quantitative comparisons, but is difficult to measure through surveys. Quantifying qualitative data is one way to approach the research problem, but there are accompanying issues of validity. Although many researchers use this technique to one extent or another, parts of the process are unclear. There needs to be a conversation among thoughtful people to build a strong bridge across murky waters.

The Intersection of My Vexations with EdTech

Cheyenne Herlandstein, *Davinci Academy*

Vexation

In our K-12 science and art charter school, I teach 8th grade science, environmental science for grades 9 - 12, and 7th grade College and Career Awareness. I am also the science department head, edtech specialist for secondary grades, and am on the committee for professional development (PD). My master's thesis two years ago included the implementation of technology standards (based on ISTE standards), the creation of educational technology (edtech) training and support for teachers, and the assessment of these pieces. My teaching and peer-support roles overlap with supporting administration in forming policies and standardizing processes related to technology. I have the opportunity to share input into each of these areas, and have an increasingly bigger-picture view of the challenges of each and how they intersect.

The first street leading to the intersection of my vexation is this: Our science standards changed last year, the Utah SEEd Standards being more inquiry-based and closer to the NGSS. This is great news for me, as I am a believer in inquiry-based education. My students and a few parents, however, have their doubts. On a regular basis last year, I heard students say that they wished I would just lecture, they missed taking notes from projected slides, they felt they were learning in the dark without starting from a chapter to read and a vocabulary list to study. Instead, I asked them to observe, to think, to figure things out, afterward giving them the vocabulary and context to describe what they'd seen for themselves.

The second street leading to my vexation contains a laptop cart, wheeling down the road. I was challenged last year to run a blended classroom for 8th graders, and was provided a dedicated laptop cart. I began the year with the idyllic notion that I could be prepared far enough ahead for students to work at their own pace, that 8th graders could quickly and easily learn the technology skills necessary to work fairly independently on Canvas, our online Learning Management System (LMS). Instead, what happened is that students often didn't do the work. I discovered they were spending a lot of time looking busy behind their laptop console. They struggled to read on a screen rather than a physical paper page, but whether this is a ubiquitous problem with the difference in media or attentional is still being researched and debated (Jabr, 2013; Margolin, Driscoll, Toland, & Kegler, 2013). Whether this was the result of the distractions waiting just a new browser window away, or a lack of true mastery of the technology, I am unsure. Inappropriate use of chat boxes, streaming music or videos online, and lack of general academic work ethic were common themes last year. My experience is that last year's students were less able to utilize technology for professional purposes than students in recent years, and were more in need than any of my students before them of dedicated instruction and social training in regards to their technology-rich lives. My requirement of a daily submission piece for accountability, about which students complained on surveys, was deliberate in trying to train them to be on task. This 2018-19 school year, we are nearly 1:1 (one electronic device per student per classroom); I may soon be called upon to help other teachers solve similar problems.

Along the road to a blended model with new science standards last year, I forgot a few best practices. Although I began the year with community-building exercises and the writing of social contracts, I felt so overwhelmed by all of the skills and concepts I needed to scaffold I didn't spend as much time on relationship-building. I didn't give myself permission to rearrange the content so that I could teach the new components related to outdoor spaces, such as the photosynthesis unit, during months the weather is more conducive to being out-of-doors. I come alive when I teach outside. My undergraduate degree is in Botany, and I am an ethnobotany geek who began her career as an informal, environmental educator. My students didn't get to see this side of me until the end of year, which was a missed opportunity for engagement.

Road three looks like working hard to influence an educational culture that prioritizes authentic engagement with technology. Steering teachers away from slideshow presentations and "tech for the sake of tech" is a big undertaking. The new SEEd Standards content created for Canvas often asks students to do something on paper, then take a photo of it and upload it to Canvas to include tech, or assigns one webquest worksheet after another. Computer use does not automatically enhance learning.

Lastly, barreling down the final road, our school has chosen to adopt a block schedule this school year. I worry about potential behavior problems that may occur in classrooms that previously had serious classroom management issues during shorter class periods. Lack of engagement leads to behaviors that erode the fabric of our school culture. Students drag hard feelings from one classroom to the next.

The crossroads that occurs at the intersection of all of my roles is this: how can we create a 21st-century learning environment where students and parents are actively engaged in accessible, inquiry-based education? How can teachers utilize technology, brain-based research, relationship-building, and best practices to become facilitators of authentic learning experiences? And how can I best support this process, when I have my own teaching gig on top of training and committee duties?

Venture

Fortunately, I have some good ideas about how to avoid collisions:

Within my own classroom, I have implemented a no cell phone policy for the first time. Unless I call for their usage, students either must have phones zipped away in backpacks or placed in a charging station I've created at the front of the room. Ideally this will cut down on distractions that waste learning time.

To better scaffold the technology skills needed for our school year, I plan to have students use class time for the first two months to practice each type of online assignment we will use during the year. This will ensure they've received the training and practice time to master the usage of these formats as homework, later. During this time, I plan to treat a missing score as an opportunity for remediation. After this scaffolding, my goal is to work towards using Canvas Mastery Paths to allow students to move between three differentiated groups of student learners. I will work with the IEP department to remediate and accommodate struggling students. I wonder, however, if this is the best course of action and am daunted by the task.

I have rearranged my standards to teach photosynthesis first in the mild autumn weather, showing my students my big, green heart on my sleeve. In doing this, I am looking for ways I might incorporate more edtech. We are not allowed to take our tablets outside, nor would I want to put them at risk doing so. Perhaps bluetooth devices for field work that could pair with their phones? In Environmental Science, I want to find a way to enhance our outdoor observations as we ponder, "Is education possibly a process of trading awareness for things of lesser worth?" (Leopold, 1949, p. 18). I have created a balance of work on and offline that I hope will strike a balance. We've begun our year by beginning a phenology journal and *A Sand County Almanac* by Aldo Leopold. Students will do the majority of their coursework on Canvas, peppered by once-per-month visits to their phenology spot, and three hours per month in stewardship service to an internship opportunity in the community, about which they will present to our class at semester's end.

In our recent back-to-school PD week, I invited teachers to rethink technology: edtech is a set of tools that supports authentic engagement, while providing empowering access to students and parents. I created authentic assignments for my students and offered to share these with peers. During PD I implemented tech in a way that we can use it to drive collaboration, modeling what we could do with students. I started the overview for our edtech training throughout this school year by introducing the self-directed learning model which uses student assessments and goal-setting surveys from the start of the year to invite them to be proactive participants in their education. I worked to revamp a prior peer-support model, the Tech Team Lead program, so that it feels more supportive and open based on previous feedback. I am also facilitating a book club for *Brain Rules* by John Medina, working to incorporate brain-based research about attention, memory, and engagement into our block planning conversations.

I started our year by inviting contributions to an organizational clearinghouse of ideas and best practices, but like last year, I fear the brainstorm fell by the wayside. Implementing guidelines for the setup of teachers' online courses is necessary for uniformity, so we can provide student and parent training and empower access. However, I fear that the training on policies regarding technology overrode the creative collaboration I was going for.

These ideas are good, but I feel like I'm all over the map. I've learned just enough to know there is so much more for me to learn. What more could I be doing with kids, regarding tech? Regarding inquiry and engagement? How could I be more creative, more efficient? How can I best support my students, my colleagues, and our school without giving up my personal life?

Vexation

Teacher educators, as valiantly as we try, can never fully prepare new teachers for the messy and complex work they need to do to create a functioning classroom where all students can learn. Our program, which prepares teachers for high-needs urban schools, attempts to reduce this complexity by focusing on particular content (Earth science) and by utilizing a cohort model in which preservice teachers move through the program's courses and teaching requirements together. In the interest of increasing cohesiveness, we are engaging in the challenging task of deciding, as a faculty, what it is that we want our new teachers' practice to "look like" in their high-need classrooms. For this purpose, we are exploring the core science teaching practices approach (e.g., Kloser 2014; Windschitl *et al*., 2012) as appropriate for our program's goals.

Research into our graduates' teaching practices through multiple case studies feeds into this endeavor through the overarching question, "What are our graduates' practices as teachers and how are they representative of the pedagogical priorities of our program?" Up to this point, we have been able to draw upon our research studies for examples – and anti-examples! – of what we hope our graduates' teaching practices will be. But our research is vexed by the fact that our program is *in the process of* developing its vision of good teaching. The attendant lack of focus is in danger of becoming more acute as we continue our program development in positive but possibly diffuse ways – which leads to our vexation description.

Some have said that core science teaching practices present the danger of focusing on a technical set of teacher skills that set aside considerations of cultural relevance and student diversity (Zeichner, 2012), We do not want to take this path. Studies in the implementation of ambitious science practices (Thompson *et* al., 2016) and high-leverage practices (Roth, Kowalski, & Bintz, 2018) are beginning to indicate that particular practices support student learning in high-needs settings. However, it is not clear that we have succeeded in showing how considerations of diversity and equity in science teaching are met by core science teaching practices. In fact, our core practices discussions and our discussions about dispositions tend to run parallel rather than overlap. This situation creates new vexations.

A possible way around these vexations is to take a different perspective. We are offered an opportunity through the very system that we often decry as unwieldy, inequitable, and intransigent: The New York City Department of Education (NYC DOE). Mayor de Blasio has recently announced that "culturally relevant education" (CRE) will be a focus of the NYC DOE (*Gotham Gazette*, May 2, 2018), especially through professional development of inservice teachers. In a text dedicated to this effort, Johnston, D'Andrea Montalbano, and Kirkland (2017) write that "culturally relevant pedagogies and practices examine instructional philosophy and practice critically, both acknowledging and searching for the presence of historical forms of oppression embedded in curriculum, instruction, and approaches to teacher-student relationships" and that "the challenge is how to solidify the theory of cultural responsiveness into concrete policies and practices that can support learning for all students" (p. 11). A fascinating and no-doubt newly vexatious question for our program becomes: How will we prepare and support teachers who are competent in implementing culturally relevant science education, as described here, in their high-need school science classrooms?

Venture

We believe that teacher preparation committed to culturally relevant science education can fruitfully take advantage of a core practices approach (Hammerness & Kennedy, 2015). But merely adding the number of practices that we teach in our preparation program would dilute the very concept and power of core practices. To avoid an additive approach and to work against the notion that culturally relevant education lives in a different world from actual science teaching practices, we are hoping to work with our graduates to 1) identify a small number of core practices to implement in their instruction, 2) posit strategies that make these practices culturally relevant (which may or may not mean adapting currently recommended core practices), and 3) develop NGGS-based lessons and units that imbed these culturally relevant core practices.

It has become clear through our research and through our ongoing interactions with teachers that our graduates greatly value their cohort colleagues and see them as one of their most valuable teaching resources. Graduates continue to stay in touch with one another after induction; many of them are eager to continue participating in the program in leadership roles. Several of our graduates have become classroom mentors in MAT partner schools. It is this growing benefit of the program's structure – that is, the two years of induction, the relationships that graduates maintain with the MAT even after induction, and the fact that several of our graduates are mentor teachers for our preservice teachers - that we aim to draw upon for our venture.

While our work in preparing teachers for high-needs settings predates the NYC DOE's commitment to culturally relevant education in the city's schools, we see this as a welcome opportunity for us to play some part in this effort. Additionally, New York State is preparing to introduce revised science standards that attend to the NGSS Framework. The third aspect of this project will draw upon our program's exploration of core science teaching practices. Thus, this study provides a potentially powerful nexus of current research-based recommendations in policy, curriculum, and instruction.

This project would include not only ongoing development and analysis of curriculum and instruction, but opportunities for collaborative research and publication. Graduates would be largely responsible for deciding on the content of video cases (including classroom video, curriculum, and examples of students' thinking about particular content) focused on shared images of core science teaching practices to support NGSS expectations in culturally relevant instructional contexts. Two tangible products of this project will be 1) curricular units accompanied by video cases written by MAT graduates supported by project personnel; 2) publications (in teacher journals as well as researcher journals) written by MAT graduates and/or project personnel.

The proposed project will also include studies of student engagement and learning. For this purpose, we will use teachers' own assessments, developed along with each lesson or unit. In this way, each teacher's students will be experiencing the same curriculum (as much as possible given school, teacher, and classroom variation) and the same assessment. This will allow for communal analysis of student engagement and learning. Additionally, surveys and interviews concerning students' interest in and learning from each collaboratively developed unit will be conducted by personnel outside of the classroom. This will provide a rich set of data – from the student, teacher, and researcher perspective – from which to develop findings about students' perceptions of and learning from each curricular unit.

Many of the participants in this conference have been working with practice-based teacher education for years. I hope that this discussion will include discussions of work with inservice teachers around core practices and culturally relevant education – especially how to balance the different kinds of expertise that all participants bring to the table. While there isn't room for it in this proposal, we do have a plan in the works that we will share at the conference itself to provide more grounding for the conversation.

Questions for Discussion

In order to provide a shared grounding for the project described above, we plan to create a framework that grounds recommended core practices in the principles of CRE. For this discussion, one core practice important to our program – "eliciting students' ideas about observable phenomena" – will be shared as an example of this effort and to begin the conversation concerning the questions below.

1. Which core practices would be the most appropriate for adopting or adapting for culturally relevant science teaching as described by Johnston et al. (2017) (see above)?
2. Johnston et al. (2017) caution us to not operationalize CRE as simplistic techniques that sidestep the historical and current inequities represented in our educational system. What should a framework that ties this aspect of CRE to specific core teaching practices look like, keeping in mind that the framework should attend to CRE theory while also describing science teaching practices?
3. As described above, our program is in the process of deciding upon a set of practices that make our program what it is. How can this project and the products and the thinking that could come out of it inform our preservice program?

Looking for Noyce Proposal Advice

Angela Johnson, *St. Mary's College of Maryland*

Vexation

I am one of the founders of the MAT program at St. Mary's College of Maryland; we just graduated our 12th cohort. This program provides a strong teacher education to about 30 students each year, including around 4 science and math teachers.

Strengths of our program:

- *Year-long internship with effective mentors in diverse settings*: Our interns complete two placements with mentor teachers hand-selected by the school district; at least one is in a Title I school or similar.
- *Title I-ready grads*: our graduates seek out the kinds of schools other teachers are afraid of—even Baltimore City, the most-feared school district in our state.
- *Reasonable cost*: about $20,000 for an intensive 10-month program; right in the middle of the pack of similar programs at public institutions in my state.
- *Great hiring rate*: all of our graduates who apply for jobs in-state get hired quickly.
- *Well-regarded by employers*: principals in our local districts favor our grads, and tell us that they are more well-prepared than other new teachers.
- *Cheerful alums*: Last year we had an 80% response rate to our alumni survey; last week I reached out to our 5- and 10-year-back alums to be sure we had the right contact information from them, and almost all of them responded to me within a day. They feel that we prepared them well and that we care about them.

We face two persistent problems, and I hope that Crossroads attendees can help me with both.

1. *Cost*: Although our cost is reasonable compared to other teacher education programs, it's still a lot of debt for a 21-year-old to take on, especially compared with alternative certification programs.
2. *Diversity*: Although we are making strides towards becoming more diverse, most of our graduates are still White middle-class women.

I believe that both of these problems can be addressed at once, by finding ways to reduce (or eliminate) tuition costs. The advice I'd like from Crossroads attendees is how to find financial support for our science and math candidates. Before I get into my venture, I want to make a list of actions we're already pursuing to address cost and diversity.

1. Looking for grants (which will be the topic of my venture)
2. Working with our local district to create a system where our grads could use their annual professional development funds to pay their student debt, or where the district will hand-select some aspiring teachers and pay their tuition up front in exchange for a promise of working in the district
3. Working with the fundraising professionals at our college to find private and public sources of funding (we already have more endowed scholarships than any other program at our institution, including a brand new $2000 scholarship for aspiring teachers of color)
4. My colleagues and I teach in our college's leadership program for under-represented students, and this has been the single biggest tactic we've found for diversifying our pool of aspiring teachers

Venture

It seems to me like an obvious step is to apply for a Noyce grant. I could really use advice about this.

Question 1: Which track?

My first thought is that we should go for Track 1, Scholarships and Stipends. If I understand the program correctly, this would let us offer scholarships of $10,000 per year to aspiring science and math teachers for their junior and senior years as well as their MAT year. Track 2 might also work for us; it would entail offering $10,000 per year for the MAT year and a $10,000 salary supplement for graduates' first four years of teaching. However, in my experience, we lose aspiring teachers not because of later salary considerations but because of the up-front costs of teacher education.

Question 2: How to talk about our program

I am thinking of building the argument that our graduates should be supported because they will be culturally relevant, diverse and AP-ready. Please help me figure out whether this is a good approach and whether there are other ways to argue why we are special enough that we should be awarded this money.

AP-ready

We don't have tracks through the majors; as a result, our science and math teachers are prepared to teach AP content. As evidence, they typically score above the 75th percentile on Praxis II content tests.

Diverse

Right now I know about several undergraduates who intend to become science and math teachers and who come from under-represented groups—a Latina who wants to be a biology teacher, a Black man who wants to teach chemistry, a Latino who wants to teach math. There may be more as well. I think I may have also recruited two future math teachers who are African American—I have been working closely both of them and I very much hope they have accepted our offer of admissions. We have strong aspiring teachers in the pipeline; I have to trust that if this is the case now, it will continue in the future — even more so if we can offer Noyce funding.

Culturally relevant

All our students show significant (and sizeable) increases in their self-efficacy around cultural relevance from the beginning to the end of our program.

Question 3: What program components should we add to increase our numbers of math and science teacher candidates?

I have been thinking of various ways (besides simply having scholarship support) to increase the numbers and quality of our aspiring science and math teachers. Please comment on my ideas and add your own!

1. Work with our admissions office to build recruiting for this program into their overall recruitment strategies; in particular, target high school juniors and seniors who are participating in the various STEM magnet programs at high schools within 60 miles of my campus.
2. Every first-year student at St. Mary's must take a first-year seminar. Create a seminar that would attract aspiring math and science teachers, and possibly co-teach it with a colleague from math or science. It could include a field placement in a local school—maybe even with a stipend for participating in the field placement. Ideas about topics?
3. In addition to a dedicated freshman seminar, I can go to intro classes in all the STEM gateway courses to urge students to consider a career in teaching. Many of my math and science colleagues are strong supporters of our MAT program; I can ask them to recruit as well.
4. Aspiring teachers are required to complete our six-course educational studies minor. I would like us to build some sort of STEM education thread through the minor—I will need to think this through further. Perhaps a monthly seminar for people who hope to receive or are already receiving scholarships, that could include field trips, invited speakers, something else….
5. Many, many St. Mary's students complete senior projects; senior projects are required in some of our science majors. Perhaps we could offer stipends (in addition to the scholarship) for aspiring science and math teachers to carry out senior projects in science and math education.

Question 4: Practical advice about the Noyce grant?

1. What kind of funding should I ask for? What can I ask for besides the actual scholarship money?
2. How much effort will it be to administer the grant? Should I build in a course release for me and/or my co-PI? Maybe two course releases, so one of us can handle it in the fall and the other in the spring? Is this even permissible to ask for?
3. Can I build in funding for the program components I sketched out above?
4. What else can you tell me about what I can do to increase the likelihood that the grant will be funded?

Question 5: Other funding source ideas?

Science void of the Natural World: Providing authentic experience for science teacher education

Adam Johnston, *Weber* State *University*

Vexation

When my daughter was 15 years old, she took her driver's education course online.

Of course, being taught online to drive is ridiculous. And, it's true. Fortunately, this wasn't the entirety of the course. There was actual driving that took place, and to be fair the online portion of the course had information that you don't provide necessarily during the "hands on" portion of the driving instruction. There were snippets about distances and statistics about accidents. Anna wears her seatbelt and pays close attention to which way to turn her wheels when she parks along a curb on a hill, and this might be attributable to her experience watching videos on a screen.

On the other hand, she wasn't especially inspired to drive by watching these videos. More important, she got no sense for the feel of driving by completing these modules.

I don't teach driving professionally, even though I'd like to think that I have a calm and helpful demeanor when riding along with either of my daughters as they've learned to drive. I can't say what's best for that mode of education. I bring up the online driver education example simply because it sounds a lot like other educational settings where it's less apparent that there's this stark contradiction between what we want the student to learn and what the student actually practices. For example, I keep getting ads from an educational platform that will let students "engage" with material in my class through their phones; and the company exalts that their platform allows for all my lectures be like TED talks. Their ads show rows of happy students looking dedicatedly up at an instructor from the organized structure of the lecture hall. As happy as the students in these stock photos look, I think that they're doing the equivalent of taking driver's ed online. They aren't getting a feel for the "driving" of a scientific discipline.

To me, "learning" can mean lots of different things, and this includes some core ideas, some overarching structures, and some practices of science. I don't think any of these come easily, and many, especially the practices of science, have to be, well, practiced. But I think there's an even bigger divide. I want students to really *feel* and experience science and the natural world. Otherwise, we're running some kind of virtual reality rather than real science. There are plenty of movements in science education that seem to fray that braid between the natural world and our scientific construction of it; and in some cases I think we unravel it completely.

For its part, current movements in science education promote and even rely on having students engage with phenomena of the natural world. These provide a starting point for students to wonder, question, investigate, and the like. Sometimes these come from firsthand experiences that can be had in a classroom or at home, but sometimes we need to scaffold these with some kind virtual connection, or sometimes we harvest phenomena that others have experienced—a volcanic eruption on a distant island, or the seeming permanence of some rock face in the middle of the desert. I think we get so good at providing these kinds of resources that we forget to find ways to put the proto-scientist into those places of nature when we can. Moreover, I think that our preservice teachers and probably even our teacher educators lack some of those firsthand connections to the natural world. For my part, I think there's no equivalent substitute to experiencing a place in all its physicality. Those experiences can be relived; they always present newness.

So, here's the thing: There is a nature out there, and for me this provides some place of inspiration. Moreover, it's *the* place where nature is actually doing its thing. If we want to understand it we need to wonder and question; and in order to do this we have to have our selves immersed in it. Otherwise we're learning to drive without actually getting behind the wheel. We're providing science that is stripped of nature, and I feel that this strips us of an intrinsic wonder and connection. I'm especially concerned about how this affects science teachers (at all levels) and science teacher educators. I'm left with my personal challenge: How can I provide opportunities to instill a sense of awe and wonder of the natural world in science teacher education?

Venture

Let's be reasonable. I can't possibly bring every student to every potential direct experience with nature that I can imagine. This is why we read, model, watch, imagine, and more generally communicate. The astute reader can see where I'm going, though. I'd like to throw teachers into the natural world.

When I say this out loud, it sounds a little silly. Obviously, we're all out in a natural world of one sort or another. There's dripping water and friction under our feet; we move through air and respire continually. These are all fun and valuable to conceptually immerse ourselves in. Yet, we're distractible. I'm looking for a more intensive encounter. This hunch and direction come from my own personal experience and the value I take away from a week in the desert or mountains. These are transformative. Waking up in the desert or setting foot on a mountain pass is a fundamentally different experience than reading about it or seeing photos. Putting hands on sandstone or feeling the motion of a river create an essence that a person doesn't feel any other way. (Edward Abbey, Terry Tempest Williams, John McPhee, Annie Dillard, and so many other authors work magic in creating a description of these, but they all know that the descriptions still fall short. Otherwise, writing would be finished—we'd have said all that was necessary to say already.)

As I can't bring every student into every natural environment, I need to start with some kind of a core experience for a core group of people. Perhaps what I'm looking for is a way to prompt some dissatisfaction with science that's devoid of nature by giving these educators an experience that sets a standard for them and what they might strive to provide students with in their own settings.

My basic proposal is to bring a group of teachers, teachers-to-be, and/or teacher educators into an immersive natural setting. While I think I could lead a backpacking trek with a few hearty people who would be patient with my "leadership," I think I need to partner with a more established facility and partners that can help scaffold the experience. I've beta-tested some experiences with the *Canyonlands Field Institute*, as well as some other field stations and interested parties; and I've also led some successful trips into mountains and deserts. So, I may have some basic understanding of how to pull this off.

At first, it seems like my biggest challenge might be just to convince people to head to southern Utah and sleep in a tent or something similarly remote and rustic. But I think that this is really just my initial challenge. Once I get people to willingly assemble in such a setting, what do we do? My own sense (and experience) is that by just being on a trail or writing in a notebook under an arch is all that anyone could need to be transformed. I think, however, that there must be a different kind of scaffolding that needs to take place; and there must be some other kind of process to bring people into an experience that they can have on their own terms.

Additionally, while I want teachers to embrace the feel of the desert, its geology and ecosystems, I imagine that there's also a parallel structure that they would expect. There probably needs to be some kind of curriculum that goes along with their experience which provides an anchor in traditional science learning. That is, maybe we are learning to identify geological layers and their distinguishing features relative to one another; but the ultimate goal is to incite awe for the expanse of geological time.

So, here I am with a sense of pieces that we would need: the teachers, partners (e.g., CFI, naturalists, guides), myself (because if I'm honest, the reason I'd want to do this is to have an excuse to have these experiences for myself!), and a stage where we can provide authentic, meaningful, and accessible science in a natural context. I'm sure there are great models out there for this, and I've had experience bringing teachers and others into these settings before, but now that I'm imagining this from scratch, there could be so many possibilities and pitfalls I'm not aware of. I know, however, that there's much to be gained by simply getting people out into these settings, away from others but together with other expertise and sensibility, in settings that simply need to be experienced in order for something more to be possible.

I'll pose a few focused questions that weigh on me that others may be able to help with: *Are* there models for these kinds of programs that I should borrow from? Who do I start with? (I've imagined three levels: preservice teachers, inservice teachers, and teacher educators. I'm not sure if it's a strength or weakness to bundle this trio of needs, and I'm not even sure if it's practical.) What kinds of outcomes should I expect, and how do I both gauge and aim for such?

Vexation

For the past three years, I have had the opportunity to work in one of the most affluent Black majority communities in the US — a place with tremendous community capital, and one that sharply contrasts its underfunded school system. My work (funded through an NSF ITEST grant) has focused on developing the practices of 42 middle school science and mathematics teachers of color across four schools to design and implement culturally-relevant engineering designs to teach science, math, and engineering practices to students through social justice issues. These teachers are veterans, having taught in the county for an average of 15-20 years. They are currently learning how to implement the Next Generation Science Standards (NGSS). Approximately a quarter of these teachers are not licensed to be science teachers and have taught in numerous subject areas during their teaching careers. All of the teachers rely on heavily scripted curriculum provided to them by district curriculum specialists that offer *suggested* activities, questions, and lectures for each day of every unit.

Originally at the time of the grant's conception, the goals of this design-based research study (Fishman et al., 2013) were two-fold. We hoped to: (a) build teachers' efficacy to teach the mathematics and science practices through professional development (PD) that trained them to co-create engineering design challenges with local and national engineers of color, and (b) develop students' interests and ability to see themselves in engineering through a culturally relevant model of teaching that utilized engineers of colors as classroom role models. Drawing from our student-centered objective and based on the work of critical scholars, we hypothesized that if teachers could relate engineering instruction to their students and show how it may transform social and racial inequities (i.e., culturally relevant engineering) then students would be more motivated to use the engineering practices and identify with professionals (Gay, 2014; Khalil & Kier, 2017; Ladson-Billings, 2014). To build teachers efficacy to create culturally relevant engineering design tasks for students, we tasked them with becoming owners of their curriculum and forging connections among the *content*, *science, math, and engineering practices*, *students' interests,* and the video-created *stories of local and national engineers of color*. The PD and tools that we provided to teachers to create these model lesson plans were iteratively designed based on teachers' products and feedback in focus groups and interviews.

In multiple sessions of blended PD, we provided teachers with models of engineering design challenges that could be problematized by science and social inequities and linked directly to students and engineers' lived experiences. We trained engineers of color to create storyboards and videos for teachers that illustrated how their work relates to social justice challenges and middle school science concepts. For example, in one of the videos, a systems engineer describes her educational pathway, her career a at nuclear generation station, the process and monitoring of waste heat treatments, and how hurricanes and tropical storms have limited access to electricity to people across the world. She discussed how the resources and infrastructure in poor areas impact the ability to recover from these disasters and constrains the designs of solutions. Specific to this engineer's story, we facilitated conversations with teachers about how they might engage students in discussions about the role of structural racism and poverty in areas populated by people of color. We hoped that by providing tools for teachers to become creative designers of their curriculum and showing how engineering can be a tool to design for social justice, we could create transformative opportunities for students in mathematics and science classrooms.

Based on the preliminary quantitative data, teachers have increased efficacy with implementing engineering in their classrooms *and* students' interest in pursuing engineering each year of the grant. Teachers have increased their use of engineering design challenges within their math and science instruction. Focus groups suggest that teachers value using tools and strategies to elicit students' worldviews and build relationships between the *whole child* and engineering challenges. However, in our analyses of teachers' pre-planning guides and lesson plans, we are not capturing how teachers are effectively integrating stories of engineers and social justice issues into the storylines of their lessons. Essentially, while we have rich data sources that teachers are *talking the talk* about the value of *culturally relevant* engineering designs, we have fewer clear examples of teachers *walking the walk* in cohesive lesson plans that integrate the engineer's story and the social justice discussions with the engineering practices. I am vexed by best practices of researching and implementing culturally relevant engineering within standards-based math and science classrooms where teachers rely heavily on scripted curriculum. Is it unreasonable to expect teachers to create coherent storylines between the four components of our model and how might I better scaffold PD and measuring teacher growth?

Venture

My venture focuses on re-approaching the current model of implementation and the ways in which I am measuring teacher growth in becoming more culturally relevant in engineering instruction. How might teachers be able to more feasibly connect their curriculum to engineering for social justice *within the scope a scripted curriculum and standards-based assessments*? I think that there needs to be a more scaffolded approach for bringing together the pieces in professional development [content/practices/engineer's story/students/social justice] that includes how to build teachers' knowledge of current issues and how their own curriculum relates to it. It seems that some teachers that I have recently worked with have lost sight of where their curriculum lives in the real-world and even more so in where it lives in their *students' real-world.* What are innovative approaches for getting teachers to step away from the script, reimagine their curriculum, and envision a new storyline that includes social justice issues that affect students?

To logistically tackle this, I wonder if supporting 6^{th}-8^{th} grade teachers is too expansive. Should I focus on a smaller, more grade-specific implementation, so that I can model more content-related units for teachers during face-to-face professional development? I want teachers to be able to explicitly address *why students should* care about what they are doing. Often teachers are making assumptions about what their students care about and what aspects of instruction students are motivated by. Are there models for PD that *include students* in vetting curricular designs? Would it be helpful for students to give formative feedback to teachers about teachers' curricular designs in meaningful way where their voice could shape the structure of units? I am intrigued by including students in professional development. I wonder how students could illustrate to teachers how to better incorporate their voice into social justice-based challenges. Further, how might I show them that they are able to balance students' perspectives and still meet their standards?

Perhaps an easier approach would be to reconsider the training and role of engineers and how they collaborate with teachers. We have faced considerable challenges on our current project with scheduling times for teachers and engineers to connect as our engineers are volunteers and minority role models with overwhelming demands on their time. Is there a better way to frame a learning/outreach opportunity for engineering students in Historically Black Colleges and Universities to work with teachers and students? Would it be worthwhile for college engineering students to review teachers' curricular designs? I wonder how they could be more of a resource to teachers and a bridge between teachers and students to ultimately increase the impact of culturally relevant engineering units. It might be interesting to research how collaborating with teachers influences the professional identities of engineering students as well. I have big dreams of interdisciplinary teaching, learning, and creating that is being stifled by high-stakes testing. How can I converge these dreams with the realities that these teachers face while supporting students to use science and engineering as a transformative tool for social justice?

Space for Appreciation in Science Education?

Karen Lionberger, *University of Georgia*

Vexation

appreciation

noun | ap·pre·ci·a·tion | \ə-ˌprē-shē-ˈā-shən , -ˌpri- *also* -ˌprē-sē-\

1 a : a feeling or expression of admiration, approval, or gratitude • I want to express my *appreciation* for all you've done. • a small token of our *appreciation*
b : JUDGMENT, EVALUATION; *especially* : a favorable critical estimate
c : sensitive awareness; *especially* : recognition of aesthetic values • a class in music *appreciation*

The appreciation for thinking and working scientifically is certainly polarized in the United States. While it may feel that this polarization has become increasingly stark more recently, it's certainly not a new issue. Recent research has shown that the general attitude toward science has declined over the last five years (Pew Research, 2015). I fully realize that it is a messy space when thinking about the many facets that contribute to people's attitudes about science, but lately I've been wondering what contributes to people developing a genuine appreciation for science. Thus, appreciation for science, or rather lack thereof, is the focal point of my vexation. As a science educator my thoughts on this issue constantly build on one another as I continue to ask myself…

Why do I feel, in some part, responsible for the decline?

How can science education better bolster appreciation of science?

As these questions emerged in my mind, I first asked myself, "*should* I feel a responsibility to play a role"? In searching for this answer, I realized that the word appreciation (or appreciate) appears numerous times throughout the *NRC Framework for K-12 Science Education*. Most instances occur in concert with an aim of developing students' appreciation through a focus on the science practices as a means for assimilation into the type of thinking and work scientists do. In one instance the authors indicate that one of the <u>main</u> goals of the revised standards is to ensure that "*all* students have some appreciation of the beauty and wonder of science". Such a lofty goal engenders new questions about what they envision as the end-products of garnering this appreciation? Is it Merriam's first definition of simple gratitude or should our aims lean more into the third definition of recognizing the benefits of science on our society? Also, since the use of the word appreciation in the *Framework* comes with a strong attachment to the science practices, is it implied that mere immersion in the science practices (and let's pretend for a moment that is actually happening) allows students to genuinely walk-away with an appreciation for science?

Let me provide a more tangible context to my vexation since it will prove useful in understanding my venture. Over the last year and a half, I have been working with in-service biology teachers on piloting modeling-based curriculum materials in their classrooms. The curriculum is aligned to NGSS and uses the practice of modeling as a catalyst to other science practices, such as analyzing data, using mathematical thinking, and constructing explanations and scientific arguments. The teachers participate in professional development (PD) and all lessons are designed using educative curriculum principles (Schneider & Krajcik, 2002). Therefore, both the PD and the lessons explicitly highlight using modeling-based instruction as a means to engage students in practices that allow them to think and work as scientists do. Preliminary results of surveys and interviews used to assess teachers' attitudes about modeling-based lessons indicate that teachers continue to value instructional activities that focus on simplistic acquisition of vocabulary over all other instructional strategies, such as modeling. When specifically asked about the potential benefits of engaging students in modeling only one teacher, out of 56, indicated any type of benefit connected to the idea of having students "think like scientists." Therefore, a true divide remains between the goals of teachers versus standards. When asked, teachers ranked the most important instructional goal as learning vocabulary. These results seem to provide continued evidence for Papadouris, et al. (2016) as they feel teachers often "prioritize students' acquisition of scientific knowledge in a final form, failing to recognize that the appreciation of philosophical dimensions in the enterprise that generates scientific explanations is as important as the knowledge of a set of canonical scientific explanations" (p. 220). Walking away with a laundry list of biology vocabulary terms etched in one's mind doesn't exactly yield appreciation for science.

Venture

Over the next three years I am continuing the modification and piloting of the educative biology curriculum materials with in-service teachers in several different states. This is a wonderful opportunity to continue to reflect on and revise the professional development and educative components of the course as a means to examining connections, if any, in influencing teachers' attitudes and classroom practices. Therefore, I would like guidance from Crossroad participants on the following questions that will guide these changes to professional development and the educative components of the curriculum materials:

First, a consideration of whether a focus on developing science appreciation is worth isolating as a separate and explicit instructional aim in the biology curriculum – Is there something more to developing a genuine appreciation for science that is unique from what we currently consider a functional scientific literacy, in part achieved through engagement in the science practices? If so, what are the potential tangible benefits and/or consequences of an explicit focus on developing students' appreciation of science? Yes, I'm asking us to invest philosophically in thinking about whether or not this is a worthy and necessary endeavor. "Philosophies often function as tools for stepping back from immediate situations and seeing larger purposes. In doing so, they become catalysts for new ideas and fresh perspectives" (Pugh, 2011, p. 108).

Guidance on the research that can illuminate my thinking and steps towards revision and instruments for measuring effectiveness of a curriculum that targets appreciation – I want to think broadly here. I have been recently digging more fully into works that consider "aesthetic understandings", thus returning to core ideas by Dewey. I have been reading work from Girod and am more recently considering how Pugh's work in defining and measuring "transformative experiences" may help inform a productive methodology that targets a composite in which appreciation is a productive component. While I am certainly open to any additional science education work that could guide my thoughts, I also want to be innovative in leaning on other disciplines that may have thought through similar issues. For instance, how do disciplines who are already positioned to explicitly focus on the goal of appreciation seek to define and achieve this – e.g., music and art appreciation education.

Suggestions on potential focus areas for educative curriculum materials – According to Girod et al. (2003), "science learning is something to be swept-up in, yielded to, and experienced" (p. 576-577). In my mind, these types of classroom experiences would be a must if we are to develop a true appreciation for science. However, in examining much of the current biology curriculum materials available to teachers, it certainly doesn't feel like something that students will get "swept-up in." My early thoughts about ways to evoke this in our revised biology curriculum are:

- ***Learning situated in compelling phenomenon*** – Ensuring that every concept is elicited through engaging with compelling phenomenon. Giving contexts and problems to students that are worth wondering about, worth solving.
- ***Tearing down of content walls*** – Currently most biology curriculum is taught through isolated content units which inherently weakens the possibilities of demonstrating the "wonder and beauty" of the natural world. In order to situate learning in compelling phenomena, we must reduce teaching fragmented content "topics". Instead, lessons will leverage concepts because they are needed to solve a problem, not because they are the cannon of topics to be learned in that unit.

What does this look like? For example, an investigation into lactase persistence in humans should naturally require students to invest thought in concepts of <u>DNA mutations</u> that led to the ability to continue to digest milk past juvenile years, an understanding of how those mutations led to the new phenotype of lactase persistence <u>via protein synthesis</u>, use of inheritance <u>models such as pedigrees</u> to trace how this phenotype has persisted in different geographic regions, and finally leveraging concepts of <u>natural selection and convergent evolution</u> as explanatory forces in the persistence of that phenotype.

Beyond the "Method Course" to Integrate Language/Literacy Development with Ambitious Science Teaching in Support of English Learners

Edward G. Lyon, *Sonoma State University*

Vexation

My colleagues and I are in the sixth and final year of our NSF-funded Secondary Science Teaching with English Language and Literacy Acquisition (or SSTELLA) Project. The project goals were three-fold: (1) develop and implement restructured secondary science teacher preparation program elements, namely the science method course across multiple universities to support novice teachers in teaching science to English Learners, (2) research the impact of the project intervention, and (3) develop multimedia tools, such as video case studies, to share with other science teacher educators. Our secondary science teacher preparation program intervention centered on the "concept" of a synergistic and reciprocal foci on science teaching *and* creating the conditions for language and literacy development. This synergistic and reciprocal foci was articulated through an instructional framework consisting of nine interrelated instructional practices organized around four dimensions: *Contextualized Science Activity*, *Scientific Sense-making, Scientific Discourse, and Language and Disciplinary Literacy Development*. Science method instructors across the various participating programs collaborated to restructure the respective courses to both address the four practice dimensions and take a practice-orientated approach in the course where PSTs experience project practices (via instructor led lessons and videotaped exemplar teaching), deconstruct and analyze practices, and then approximate themselves in class.

At this stage in the project, we have finished data collection with data that include: (1) PST survey, interviews, and observations, (2) secondary science method instructor observations, and (3) student learning outcomes from program graduates when in their second year of teaching. We have also conducted preliminary analyses to help us establish proof of concept – can pre-service teachers implement our project-informed instructional practices as intended, and does this implementation differ from a control group of pre-service teachers who received the "business as usual" method course (see Lyon et al., 2018).

From initial analyses, we have detected some patterns in teacher practice and change in teacher beliefs that show promise for the project intervention. For one, in multiple teacher preparation programs, a majority of pre-service teachers were enacting the instructional practices, "Student Talk" and "Student Interaction," as intended and the measured level of enactment reflected a positive change from the control group in these same programs. We are also beginning to see differences in how the pre-service teachers changed in their beliefs toward teaching science to ELs, as gauged through pre-post interviews, as compared to the control group. While these overall findings are encouraging, pre-service teacher implementation varied considerably from each other. This variation was expected and we feel a strength of the project to understand the ways in which we may need to support PSTs differently. We collaborated with science method instructors from Texas, Arizona, and California – reflecting both undergraduate and masters' programs.

Our team still has a lot of potential directions in terms of analyzing data, including qualitative analyses of teacher practice, relationship to student learning outcomes, and more rigorous analysis of program impact. Yet, there are particular aspects of our project design and findings that have always vexed me. For one, while it was encouraging to see PSTs in our program supporting ELs by emphasizing classroom interaction and talk, we saw less evidence of planning instruction through big ideas in science or engagement in science practices. In some cases, the intervention group implemented these practices as a lower level than the control group. This makes me wonder about the unintended consequence of sacrificing scientific sense-making opportunities when attending more heavily to language and literacy development, despite our premise around the integrated nature of these practices. Second, our design was limited in that we primarily focused on restructuring the quarter or semester long science method course at each site, with some brief training for supervisors/ mentor teachers in the student teaching semester. A situated perspective asserts that people learn as they deepen their participation within a community of practice (Lave & Wenger, 1991). A method course certainly reflects a community of practice, yet in teacher preparation programs it is notoriously difficult for candidates to navigate and learn within and across the seemingly disparate worlds of university coursework and field placement (Kretchmar & Zeichner, 2016). What would happen if we found ways to bring together what PSTs were learning around language and literacy development when teaching content area instruction with what there were learning through field experience, and perhaps more importantly help them navigate both worlds?

Venture

Given the promise for a model of integrating language/literacy development with science instruction for English Learners in secondary science teacher preparation as well as its challenges and likely shortcoming in practice, I am now (with colleagues across multiple universities) writing a proposal for NSF's DRK-12 program (teaching strand, late stage design and development) to understand how how to enhance opportunities for a greater proportion of secondary STEM (i.e., math and science) pre-service teachers in any given teacher preparation program to successfully teach in ways that support ELs. Our proposal is built on several key principles...

- Having a coherent instructional framework that articulates ways in which contextualized language/literacy development (i.e., the SSTELLA dimensions) can be more explicitly addressed in ambitious science teaching (Windschitl, Thompson, Braaten, & Stroupe, 2012) to ensure sense-making and discourse opportunities are not sacrificed
- Focus on PST experiencing, analyzing, and approximating core practices
- Effective and practical mechanism for supporting and collaborating with mentors of PSTs
- Seamless and sustained connections between PST learning through university coursework and field experience

A central goal is to establish a proof of concept that a STEM teacher preparation program (incorporating the key principles above) can be carried out in different universities. Yet, Bryk et al. (2015) argue that traditional notions of fidelity of implementation need to be complemented by the idea of integrated adaption—to see how good ideas can get taken up in unpredictable and complex local environments, in ways that might necessary deviate from the "checklist" approach to faithful implementation (Bryk et al., 2015, p. 209). In this spirit, we plan to run a pilot version at one of the universities that has already developed tools, activities, and partnerships that attend to the key principles. For example, we have developed a "Core Practice Framework" that begins to articulate how to contextualize instruction while planning big disciplinary ideas and eliciting student ideas. Our math and science method courses are set up so that PSTs iteratively experience a core practice and have supportive opportunities to rehearse the practice in both the method course and field placement. We also have a partnership with Trellis Education who bring STEM mentors together to collectively learn how to mentor candidates around core practices. Trellis also has partnerships with the other universities in our proposal.

During the project's first year, we will meet as a whole project team to (1) share resources already utilized (e.g., tools, activities, partnerships), (2) learn ourselves about integrating language and literacy more deeply into science instruction through experts in the field, and (3) provide feedback to each other as we refine our STEM teacher preparation programs. We will then carry out our refined programs over the next two years, as we continuously reflect on what is being learned. Throughout, we will carry out "Proof of Concept" research through surveys, interviews, and observations of method instructors, mentor teachers, and PSTs as well as documentation of program design and implementation. Our goal is to produce a model and resources that represents the essential features of preparing STEM PSTs to teach ELs as well as specific ways to adapt programs to different institutional contexts.

Crossroads is a fantastic opportunity to solicit targeted feedback as we refine the proposal that is due in November. From crossroad attendees, I really want to hear reactions to how we are developing and testing a STEM teacher preparation model that is situated across multiple universities and that will lead to research and products that can impact the field and practice. In particular, feedback is desired around:

- How we are developing and testing a coherent model, even if we are not all implementing a program in exactly the same way? In other words, treading the fine line between standardizing and adapting to our own institutional contexts.
- Is it clear what the true focus and merit of the proposal are? For instance, what is at the foreground and background of the project (is it MORE about supporting the teaching of ELs OR how we prepare teachers through deeper integration with/support by mentors in the field placement?) Or does this foreground/background question not matter?

Principal Network Development through Community Science Leaders

Stefanie Marshall, *University of Minnesota-Twin Cities*

My Vexation

I write this as a researcher, scholar, and as a Black woman. In 2014, I served on a panel of Black professionals for a group of high school students from Flint, Michigan. As a second-year graduate student/apprentice, I was just beginning to accept an identity as a researcher. However, what I always knew was that I could do science. During that panel, an African-American young lady asked me towards the end of the panel discussion, "how did you know you could do science." My response was, "I didn't know that I couldn't." This story grounds my thinking about science. There are adults and people in power who are systematically creating environments each day that are telling students, especially those of color, that they cannot do science. For this reason, I am interested in the systemic and organizational challenges that exist in supporting science.

Today's reality for science in elementary schools is that it is often treated as either an elective (taught once per week), not taught in lieu of other subjects, as optional, or it postponed until standardized testing is completed (Carrier, Tugurian, & Thomson, 2013; Milner Sondergeld, Demir, Johnson, & Czerniak, 2012; Spillane, Diamond, Walker, Halverson, & Jita, 2001). This limited exposure then decreases the science identity students possess. Key decisions concerning time, resources spent, professional development to be allocated towards specific content, and maintenance of policies is often based on decisions made by the school principal, holding principals fully responsible since the induction of No Child Left Behind (Spillane & Hunt, 2010). Researchers have argued that principals spend the majority of their time on administrative tasks (Spillane & Hunt, 2010), and often times delegate instructional matters to instructional coaches (Domina, Lewis, Agarwal, & Hanselman, 2015). However, others have found that as much as thirty percent of a principal's time in today's accountability era is on instructional matters (Spillane & Hunt, 2010).

The majority of elementary school principals and administrators making district and school-level decisions about science education have had either no coursework or professional development in science education since they were in college, or if they have, it was minimal. Therefore, decisions about science at the school and district level are being made based on personal beliefs and understandings, as well as how one draws from their social networks. Frank, Zhoa, and Borman (2004) discuss the need for teachers to draw on social capital in order to effectively implement innovations, and that information is diffused through systems. In my recent work about elementary principal science networks, I found that principals who draw upon their network about science in substantial ways were in essence community leaders and more innovative. They drew from a range of individuals in order to inform how science was implemented in the district. Science was a means of preparing students to return to their community as citizens who do science. In contrast, a principal who was not a community leader sought her network to fulfill district-level science related compliance requirements.

Although educators are currently beholden to Every Student Succeeds Act (ESSA), the decisions being made by administrators in regard to science still largely align to No Child Left Behind (NCLB) (Marshall, forthcoming). Although some accountability pressures and penalties have lifted (e.g. implementing Supplemental Educational Services (SES), administrators and teachers being fired, etc.) school leaders maintain concerns about rankings—specifically being listed as a poorly performing school. It is believed by some educators that students will be able to catch up in science in either middle school or high school, further validating the sacrificed time in elementary schools (Pratt, 2007).

There is a need to both re-envision and prepare principals who make decisions for science as a community member. I am calling this administrator, a Science Community Leader (SCL). I am defining a SCL as one who strategically navigates and accesses his/her own network to inform decisions about science. A principal's capacity to activate resources, making resources usable for science (Spillane, Diamond, Walker, Halverson, & Jita, 2001), is related to a principals' network and understanding the capital within the network. This is an important area to explore to better understand how to enhance the social capital of elementary principals within their network, which could result in a greater capacity to support science education. A SCL accesses resources in ways all principals need to, but many principals may not have the navigational capacities to do so—but I believe we can develop these skills. Essentially, the school principal could be the difference between students having the resources they need to be successful in science, or not.

Based on the limited conversations on the role of school principals in science education, I believe it would be of value to discuss how to support principals in engaging within their science network, therefore my vexation can be summarized in the following questions:

- How can science be understood as a community endeavor, rather than simply a content area as it is by many school administrators?
- What resources can assist school leaders in enhancing their navigation of their science network?
- How can I, along with colleagues, change the narrative about who can contribute to science understandings—that community members provide valuable expertise to science understandings?

My Venture

There are three ways I consider viable for tackling my vexation: (1) develop science network enhancing tools for administrators, (2) identify qualities of community leaders to support the development of such, (3) create a group in which scholars strive to understand the bridge between school administrators who advocate for science education and the communities in which they serve — how are they different? I will now discuss these ventures further.

One challenge in high-turnover districts is retaining institutional knowledge and adequately providing all needed information to new administrators. Another challenge with accessing one's network was that individuals may not know who can be supportive of science education within their network. Therefore, something like a "science resource map" may be helpful. I foresee a program in which administrators can enter specific information about their background, their needs, and those they believe are responsible for supporting their science network. The program then engages administrators with the expertise/information these individuals possess as well as who those individuals obtain information from and the information/expertise those connected individuals possess. It would present like a family tree where individuals in the network can be added in by others so that where information is funneling *from* and *to* is better understood. It would also provide valuable insights to state officials as to the holes in a network and what capacities may be missing to support network administrators in science.

I have found that race matters in how one makes sense of science policies. In fact, the SCL is based on observations and interviews with Black principals. I also interviewed and observed White principals, and their beliefs and understandings of science differed. Black principals have been found to serve as community leaders who often identify with the lives of their Black students and possess a personal charge to dismantle social hierarchies (Lomotey, 1993; Khalifa, 2012). Becoming a SCL would mean one is willing to disrupt what is acceptable in implementing science to serve not only students, but those within the school community. When serving a community with science, one understands the transformational opportunities awaiting a community.

Developing tools and supporting SCLs will take a group of scholars committed to considering systems and organizational questions related to science education. Science is generally not prioritized at the elementary level in US schools, but I believe that can be changed by shifting the narrative and by reconceptualizing what science is. Addressing the needs for science should be discussed in leadership coursework so that principals are prepared to address science implementation challenges once they are in the field. I am explicit about a need for a group of scholars to take on this charge given I have worked on teams where I was told systems thinking about administrators would and should be considered, and then it was later dropped from the study as it was not viewed as a priority. I believe these sociological underpinnings matter and by working with those in the field, scaling up equity driven science instruction will be sustainable. We must begin to explicitly address the role school principals and administrators by meeting them where they are.

The ventures I have vary in scale, however each venture presents differing challenges. I would appreciate my colleagues at Crossroads to consider the following questions:

- What tools could examine principal beliefs that may provide insights as to how science decisions are being made by particular stakeholders?
- How can a small group of colleagues express their concerns to the field that may not prioritize school administrators as key stakeholders?
- How can what we know about how school administrators engage in science be utilized to support scaling up science instruction?

Vexation

In 2017, while researching 235 grade 6-8 teachers' knowledge and beliefs about scientific or science literacy (Norris & Phillips, 2003), a vexing finding emerged. Overwhelmingly, participating teachers viewed integrating science instruction with the arts as increasing the quality of science instruction regardless of the quality of the science education component.

In this survey research, six critical instances or instructional scenarios designed to depict three levels of quality for best practices in developing science literacy during instruction (Not authentic, Partially authentic, and Authentic) were presented to teachers. The criteria for determining the scenarios' quality was derived from The Framework for K-12 Science Education (NRC, 2012) and the English Language Arts Common Core Standards, specifically the section on Literacy in History/Social Studies, Science, and Technical Subjects (NGA & CCSSO, 2010).

In the first scenario, a Not authentic example of best practices in developing science literacy, teachers were asked to select a rating for the scenario and provide an explanation for their rating. The scenario depicted students reading a section of text from a textbook that described how forces hold celestial objects in orbit in the solar system. After reading, students were asked to write Haiku or Cinquain poetry to communicate their science understanding.

Thirty-six percent of the participants in the study rated this scenario as Authentic for developing science literacy in students. The vexing finding was that the most frequent reason cited by these teachers for selecting such a high rating was Integrates arts (Elementary= 83.7%; Secondary=37.1%) even though the integration included in this scenario does not support increased content knowledge, nature of science understanding, or communicative practices authentic to science. This suggests that a large percentage of participating teachers may consider any integration as an "unqualified good" (Hall-Kenyon & Smith, 2013, p. 96). Perhaps this finding should not be unexpected as some research promotes the idea of integration (Sen & Ay, 2017, Switzer & Voss, 1982) and indicates that integration increases student achievement (Berlin & Hillen, 1994; Hurley, 2001).

While certain research supports integration during instruction, other research additionally suggests that effective integration is challenging (Hall-Kenyon & Smith, 2013). This may be because the definitions of what integration entails drastically differ and effective integration requires deep content knowledge and extensive pedagogical understanding in each of the integrated disciplines (Hall-Kenyon & Smith, 2013).

Currently, with the public fervor surrounding the inclusion of STEM or STEAM in K-12 education, it appears that integration is a "what's hot" topic. While there are many constructs depicting how STEM or STEAM is defined and implemented (Dare, Ring, & Roehrig, 2017), there is also questionable evidence to support that integration including arts integration deepens learning in science (Daugherty, 2013).

My vexation includes how to promote deep content learning, appropriate skill acquisition, and authentic communicative practices in the discipline of science for all K-6 teachers in an educational atmosphere that perceives unqualified integrated STEM/STEAM as a way to achieve deeper learning?

Venture

For the past two years, I have been working with sixth-grade teachers in a large school district to implement new state science standards. In the first year, the format consisted of five days of professional development for each teacher that focused on three-dimensional science instruction and phenomena (NRC, 2012) along with acquisition of deepened science content knowledge. During the second year, teachers had the option to participate in learning experiences related to various topics such as: designing quality instruction, planning a scope and sequence, writing formative assessment items, and gaining additional content knowledge.

During the same time, teachers from half of the K-6 schools were receiving district professional development that promoted the idea that deep student learning occurs due to integration of disciplines including the arts. Research on what constitutes effective instruction within each discipline was not an emphasized component of the professional development. Through the learning series, teachers were required to write integrated lesson plans. No direction was provided for including components of quality instruction or assessment within each integrated discipline in these instructional units.

Interestingly, as this occurred, a few sixth-grade teachers spontaneously voiced concerns that these newly designed integrated lesson plans did not promote components of quality science education. Their unease was noted and voiced by their principals. However, the integration trainings continued unchanged, and this past summer an additional group of teachers received the same training. Two-thirds of the district's elementary schools have now been through this professional development.

On a state level, the State Board of Education voted last summer to revise the K-5 state science standards to align with the recently implemented 6-8 grade standards. Implementation of these new standards will be in approximately two years. As an Elementary Science Specialist, I will be responsible for designing professional development for all K-5 teachers in the district. By the time of implementation, all elementary school teachers in the district will have had a year of professional development supporting the idea that integration (unconditional) is the instructional path that deepens student learning — thus propagating the notion observed in my research.

Currently, my plan is to offer optional professional development experiences for K-6 teachers over the next two years that promote quality (a) science instruction that focuses on authentic ways scientists communicate by emphasizing the science and engineering practices found in The Framework for K-12 Science Education (NRC, 2012), (b) assessment item writing that helps teachers determine what constitutes proficiency of a science standard and what tasks will allow students to demonstrate proficiency, and (c) science unit planning that starts with a standard, considers proficiency and assessment, and builds from tasks that are authentic to how scientists work in the field. Additionally, I am proposing that a volunteer group of teachers collaborate to create and implement a common scope and sequence and instruction along with utilizing new district benchmark assessments. However, these experiences feel like a drop in the bucket when compared to the blanket professional development all district K-6 teachers received concerning unqualified STEM/STEAM integration.

Possible questions for the group to consider as we explore these ideas:

1. What professional development approach can be taken that will honor teachers' current understanding of integration while challenging them to reconsider what constitutes quality science instruction?
2. How can professional development be designed to encourage teachers to evaluate what constitutes deep learning for students as compared to engaging activities?
3. How can professional development be designed in a way that displays unity of message throughout the district while promoting components of quality science instruction?

A High School Curriculum Focused on Engagement

James A. Middleton, *Arizona State University*

Vexation

In the moment versus the long haul? *Given we know that students' motivation and patterns of engagement are quite volatile, changing as they move from teacher to teacher, subject to subject, and activity to activity, how to effectively structure learning experiences at different levels of time-scale to promote long-term valuation of STEM subject matter is the central question of my academic life.*

In recent work, my colleagues and I examined the High School Longitudinal Study of 2009 (HSLS: 09), and subsequent follow-up surveys of high schoolers in the US. What we have found is that kids enter high school about evenly split into thirds: About are contemplating STEM careers, about 1/3 definitely *don't* want to continue in a STEM career, and about 1/3 are like most 9th graders. They haven't thought much about what they want to do 4 or 8 years down the road (Mangu, et al., 2016). Two years later, when these same students finished 10th grade, they were again about evenly split into the same thirds. BUT, we found that there were many students who we termed, "switchers," who originally aspired towards a STEM career but two years later *didn't* select STEM careers as potential future jobs. Moreover, there were many who originally *didn't* want to go into STEM as 9th graders who, two years later, *did* select STEM careers as their potential future options. Many from both categories became undecided while many of the undecided moved into selecting both STEM and NON-STEM careers as 11th graders. To probe into why this might be the case, we examined their motivational attitudes in 9th versus 11th grades. There was little to no correlation between students' responses in 9th grade and their responses in the 11th grade.

We interpret these findings to suggest that there is great variability in students' experiences in the early years of high school. This is following on a huge period of change (generally decline) in students' math and science motivation in the middle grades (Martin, Way, Bobis, & Anderson, 2015). Moreover, students' experiences are highly varied, depending on the teacher and the emotional and academic support provided (Alexander, Johnson, & Kelley, 2012). Some things are happening in between 9th and 11th grades that turn some kids on to mathematics and science, and some things turn other kids off, at a critical time in their academic development. Beyond about the 11th grade, there is little turning back: A student who opts out of STEM-related coursework will find little opportunity to opt back in in the future.

We are currently studying the development of mathematics engagement in high schoolers, beginning in the 9th grade and moving through the end of the 10th grade in several school districts in Arizona and Delaware (Middleton & Jansen, 2017). The role of the teacher and her/his emotional, academic, and personal support, the nature of the tasks given students and their perceptions of those tasks, the social structure of the classroom, and students' personal interests and predilections are being studied through mixed-methods, longitudinally. We are following the same kids individually as they move from 9th grade math through 10th grade, tracking the changes in their engagement in the subject matter.

A particular challenge we are finding is the irrelevance of mathematics tasks and experiences to the lives of students. As an example, polynomial functions are taught with little to no real connection to the world of work, or even quality fantasy contexts wherein the properties of these functions can be imagined as meaningful and useful. Often the science curriculum provides some remedy as mathematics is nearly always *used* in science in service to some important concept or investigation. Likewise, engineering provides utility for the mathematics. But the science, engineering and mathematics curricula are disarticulated in middle and high school. Science curricula, for example, focusing on exponential growth in biology, or statistical concepts such as correlation, uses mathematics concepts and skills that are not taught in mathematics until years later.

There is a good body of research on this issue of relevance. Two types of perceived utility (i.e., *instrumentality*) seem to make a difference in students' interest and self-efficacy related to math and science: *Exogenous instrumentality and Endogenous instrumentality.* Briefly, these aspects of utility focus first on whether or not the outcomes of what one is doing will impact the learner in the future. Endogenous instrumentality is a belief that what one is learning in-the-moment is valuable for one's future — e.g., whether or not knowing the end behavior of a 4th degree polynomial will be important for me as a biologist. Exogenous instrumentality concerns the belief whether or not the *outcomes* of my effort (e.g., obtaining grades or recognition—extrinsic contingencies) will contribute to one's future—e.g., whether or not my score of 73% on a polynomial chapter test will impact my ability to take AP Calculus (Husman & Lens, 1999). These two beliefs are tied to one's present and future goals in distinct ways: Kim (2016), studying 765 undergraduate engineering students, found that endogenous instrumentality was a stronger predictor of students' mastery goals and situational interest in the subject matter than exogenous instrumentality. In contrast, exogenous instrumentality weakened students' motivation and their achievement. This was especially apparent for students with low self-efficacy.

There isn't really a good exploitation of the large body of research on motivation, engagement, and utility in mathematics, science, or engineering curriculum design. Most attempts at motivating students appear to be surface level — embedding a task in a supposed occupation without really treating the concepts like the professional in that occupation would — or ancillary, focusing on games or music, or images that are not central to the science, or the mathematics being taught.

My dilemma is thus: What would a learning environment focused on truly engaging high school students in mathematics look like? How would dealing with relevance cause changes the ways students interact socially in the classroom? How might endogenously instrumental tasks enable students to develop interest in the subject matter? And, how would such a curriculum be woven together with science coursework and engineering experiences such that they each mutually support each other?

Venture

Building Endogenous Utility: Working Together to Fundamentally Change the High School Curriculum

As I reread *Project 2061*, and the *NGSS* and the NCTM *Principles and Standards for School Mathematics*, and much of the *Common Core*, I wonder at the inertia of a system that can't put these good ideas together to create a set of learning experiences that is more relevant and rewarding for students—authentic, if you will, to the fields that we love and call our own. What if we did just that? What if the broader learning trajectory of mathematics, biology, earth and space sciences, chemistry and physics, and engineering disciplines, were mapped out as a common (if vast) structure? What if the critically important ideas in each were identified, and the common ideas that support each discipline were *planned* together so that they could mutually support each other? I venture to say (see what I did there?) that with such a basis for instruction, the nature of teaching subjects would change dramatically. The tools for teaching would also probably change to be more useful over a longer period of time.

What I am proposing is the following. To: 1) Scrap current perceptions of the high school curriculum; Order of topics within and across courses, the distinct and separate nature of course, the notion of why we have content-specific courses at all, and time constraints and technologies should all be challenged such that the actual experience of learning STEM, and its trajectory over time, can be better envisioned; 2) Bring together subject matter experts and discipline-based researchers from each discipline to a common table to return to first principles, challenge those principles, and begin to build plausible learning progression(s) in STEM wherein ideas in one area follow from and contribute to, ideas in others. This is not necessarily curriculum integration, but careful, mutual, curriculum design; and 3) Develop tasks and learning experiences that would engage students by envisioning how their current experiences interconnect (or not), and lead to the fulfillment of their own intrinsic goals and motivation(s).

"Ideas," as Dewey wrote back in the 1920's "gain their meaning through use." I hypothesize that Endogenous instrumentality can come to rival Exogenous concerns, in turn, helping students develop interest and inclination to continue in STEM related pursuits, whether or not they end up being scientists or engineers. There are many reasons why students may turn on or turn off during high school mathematics and science. Changing curriculum has shown to be causal in changing teachers' beliefs, and more importantly, their teaching behaviors. As such a truly engaging curriculum may serve as an important lever for keeping more kids in the STEM pathway.

(W)holistic Science Pedagogy: A multi-dimensional commitment to science instruction

Alexis Patterson – *University of California, Davis*

Vexation

After the launch of Sputnik, the world's first artificial satellite, by the Soviet Union in the late 1950's, the federal government mobilized school districts to improve instruction in science and mathematics. The intention was to develop and increase the quality and number of scientists who would enable the United States to maintain its competitive edge and surpass the scientific and militaristic achievement of Russia (Raizen, 1997). While these changes may have improved the STEM pathways for some groups, there remain disproportionate representation in the STEM workforce and acquisition of certificates and degrees across ethno-racial groups. Black and Latino/Hispanic people are underrepresented in the STEM workforce, while White and some Asian people are overrepresented (Landivar, 2013). Recent STEM degree and certification data paint a similar picture. Of the nearly 667,919 science, technology, engineering, and math (STEM) degrees and certifications awarded in 2015, we see the disproportionality of White (63.6%), Black (8.6%), Hispanic (12.1%), Asian (11.6%), and multi-racial (3.3%) students (U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, 2017). While degree and employment data may not tell the entire story, they speak to larger educational trends. The disparity begins well before college, however. Results of the most recent National Assessment of Educational Progress (NAEP) data for science highlights similar performance gaps between traditionally marginalized and non-marginalized students in science (U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, 2015).

In spite of significant strides and progress, the educational attainment and instructional outcomes between groups have remained over time. As with other social, economic and political indicators of community wellness, we see disparate representation across ethno-racial categories in STEM.

As the scientific and technological divide widens, access to quality science and math instruction has become a civil rights issue (Tate, 2001; Moses & Cobb, 2001): those equipped with the knowledge and skill will remain caretakers of status and power. Invariably, students without access to rigorous science and math instruction have been and will continue to be left behind. This inequality is especially salient for students in marginalized communities and schools where stereotypes fuel low expectations for academic achievement and success. For many students, the classroom represents their earliest formal experience with both the content and process of science, placing science teachers in a unique and precarious position: getting students excited and engaged about science while simultaneously preparing the next generation of STEM professionals. For science, previous efforts to boost achievement have done little to disrupt and close the gaps between ethno-racial groups. Efforts to level the playing field have paid little attention to the enduring macro-structures and systems. Focus has been on the student, ways to engage, inspire and increase access to real-world science. Despite several efforts to shift engagement in science, a pernicious and persistent gap in STEM participation remains. Questions endure about who feels that science is a part of their identity, who can meaningfully engage in science, and whether or not science is a meaningful tool for their lives (Carlone, Haun-Frank, & Webb, 2011). Thus, we are concerned about the role of classroom instruction in perpetuating these gaps and are interested in using classroom instruction as a disruptive tool to these gaps.

Venture

We offer the (W)holistic Science Pedagogy and its five commitments as an instructional approach that can shift the perception of science and science learning by all groups. It is both a teacher and student-centered approach of instruction to escape the cul-de-sac of science reform where teachers repeat and maintain the same patterns and hierarchies in the name of change. The WSP approach requires five commitments from the teacher: A commitment (1) to an ever-developing self-awareness, (2) to science and its practices, (3) to science as a transformative agent, (4) to their students' social emotional wellness, and (5) to restorative practices. The result of an interaction between the (W)holistic science teacher and their students is the creation of a learning space and a set of experiences where students' whole selves and interests are engaged and reflected within classroom science.

When using the WSP, science teachers use strategies and tools to develop students' content knowledge grounded in a critical awareness of the structures and institutions that have created and maintained the racial, gendered and economic hierarchies in society (Powell, 2010; Bullard, 2005). A (W)holistic Science Teacher is one who recognizes the connection between students' lived experiences and their degree of participation and invariably achievement within science. Additionally, this teacher attends to the social, emotional as well as academic needs of the student in service to the greater community. As classroom and school leaders, (W)holistic Science teachers recognize the necessity of emotionally, socially and intellectually safe learning spaces for students. In practice, students and teachers are encouraged to envision and imagine ways and practices of learning that are relevant and useful to themselves, the community and society at large.

After several conference presentations with science teacher educators and leading professional development workshops with science teachers, the overwhelming feedback is that (W)holistic Science Pedagogy brings together various elements that teachers would like to incorporate in their teaching. Most teachers would like a tool that would give them a better grasp on how to enact the curriculum. Our venture, then, is to create a website that can serve as an educative resource that can introduce new science educators interested in as well as support teachers currently using the WSP as framework to guide their instruction. We envision this website housing case studies, videos, lesson plans, and interviews (or meta-conversations) with teachers who have integrated the WSP into their teaching. We have explored websites like the ***Tools for Ambitious Science Teaching*** (ambitiousscienceteaching.org/), TERC's ***Talk Science Professional Development*** site (inquiryproject.terc.edu/), and the Exploratorium's ***Teachers' Institute*** as examples.

But, how do we, a pre-tenure professor and full-time classroom teacher, accomplish what feels like a large undertaking? Our specific wonderings that would guide our incubator session would include:

- ***How would we go about gathering information, data, and network of teachers necessary for the development of a website that would allow us to create a tool that teachers can use to cultivate their expertise and ability to incorporate the WSP in their teaching?*** We have completed a small study, where we have collected video data of a veteran science teacher teaching a lesson she designed with the WSP as a guide. We also interviewed her after the lesson regarding the five commitments and the lesson design. Should we continue on this path and gather data via a research study of other teachers? Or, should we use a summer institute with teachers taking more of a professional development approach? Or, perhaps something different altogether?

- We have never built a website before. ***What considerations should we keep in mind as we start this endeavor?*** Discussion here can include issues around data management/storage, website platforms and web developers, or the best equipment and formatting for video/audio files.

- We have received a small research grant (~$2000) and are applying to several small grants to fund our work. ***Are there grants that we can apply to that are specifically for the development of technological tools or resources for teachers?***

We believe these wonderings will support our endeavors in developing a robust web-based tool for teachers interested in incorporating the WSP into their approach to teaching science. We believe that our instructional model can help increase diversity, inclusion, and the cultivation of more equitable and just science learning experiences for all students in science. Students are whole beings, socialized by way of multiple experiences, interactions, and levels of awareness. As such, educators must move far beyond the notion of overly scripted, socially and culturally irrelevant curriculum if they are to create meaningful, real-world learning. The approach must be holistic, responding to the mental, physical, and emotional needs of the students. The increasing diversity, global diffusion of knowledge, and increasing dependence on science and technology warrant a differentiation of our teaching practice. Our aim with the WSP is to provide a framework that centers teachers on science and scientific thinking as a tool of liberation, healing, and transformation.

Academic Culture, Becoming Unfiltered and STEM Education

Seema Rivera, *Clarkson University*

Vexation

Every fall I teach a course that focuses on the history and philosophy of STEM. Many times we focus more on the nature of science (NOS) because most of my graduate students have their bachelor's degrees in science or math disciplines but have never learned about the NOS. Last fall I decided to include a module on diversity in STEM. There were a few readings assigned having to do with science education, equity, urban schools, and an activity on identity. When the discussion took place and the identity assigned was turned in, I was astonished with the discourse that was taking place. Some of the comments included:

> "Maybe people are leaving urban school districts because the students, parents, and faculty stigmatize them. Maybe they are leaving because the resources aren't there to help them teach. Maybe spending 45 minutes to an hour a day isn't enough to "turn them around" when they have all the other 23 hours of influence in their life. Or maybe they have grand ideas on how to help urban students succeed and theory doesn't meet reality and they realize that urban students are typically more likely to drop out, get into trouble, and treat others (including authority) very poorly."

> "…I do not believe it [teaching in an urban school] is for everyone. When I first came into the program I was nervous to say that, but I truly feel like you are doing those students a disfavor if you are not there one hundred percent, dedicated to teaching students like that."

> "For me, I grew up in a rural area, farm country just outside of [school in the northeast]. My high school consisted of farm kids walking tall with their Redwing boots, and those who rode their snowmobiles to school in the winter. Growing up, I had dial-up internet until I was 17, and could not afford a computer of my own until college. Needless to say, I was always behind the curve when it came to new technology and styles. I would spend summers at my cousins house where they had all the cool gadgets and new toys in an upper middle class suburban [town]. As such, when I chose my internship and later on when I choose a place to work, I was looking for either rural or suburban. I chose these not because of the demographics, but simply because I would be working with students who were typically more likely to spend time outside. To this degree, in terms of Earth science, I would be able to connect with my students on a more personal level. It just made sense to me. Also, being behind the times and all, in an urban school I feel as though I would incessantly be playing catchup with the latest music and fashions and styles and vocabulary. Teaching is difficult as it is, I'd hate to make it more difficult by not being able to connect with my students."

I became concerned with the tone of the discourse. I wanted to probe and better understand how these students, all white, came to these conclusions in the discussion. I was looking for support on how to approach the discussion. Those around me told me that I "need to make sure your personal opinions do not impact how you treat your students" and also asked, "well does diversity talk really belong in a STEM class?" Additionally, several of my teaching evaluations from this course stated their dissatisfaction with the module about diversity because "it doesn't have to do with teaching science or math".

I am unsure of how to address these concerns, however, I need to continue to talk about this because it is so needed. While the class writings and discussion were a bit discouraging, I realized that until we allow students to be a bit unfiltered, we will not make progress. In a way I was grateful they spoke their mind.

Especially because my experience with graduate students has been that they know what to say and what to write to do well in class so they can continue to move forward in the program. While I struggle with this vexation, I also acknowledge how I, as a woman of color, position myself to talk about these issues in a credible way with my students?

Venture

We are graduating teacher candidates who go out and work in schools and who do make an impression and impact on students. I think it is imperative we do more, but need help in figuring out how to do this. Working in a relatively small University and being one of the few people of color on campus complicates the issue. Though, I do have control over what happens in my courses. There is substantial research that talks about white teachers and the deficit views they hold towards students of color. However, Lowenstein (2009) suggests that if teacher educators want teachers to embrace students as active learners, then teacher educators should be critical of their own pedagogies and also view teachers as active learners. The viewpoints of teacher candidates need to be reflected upon when trying to reform issues of diversity in teacher education. Instead of dismissing my students' views as completely false ideas, it may be more fruitful to view their responses as a natural part of their racial identity development.

For my venture, I want to know how we can make changes as science educators, particularly those in small departments and universities, all over the country. At Crossroads I would like to discuss, with other science educators, how issues like diversity and inequity can be incorporated and addressed in a science education class, more specifically:

a) What supports and resources are available and/or needed to support science education faculty to develop the knowledge and skills needed to make these instructional shifts?

b) How do we encourage our students to share their unfiltered thoughts on diversity and inequity in STEM in class?

c) What kinds of course activities are preservice teachers more receptive to when addressing diversity and inequity in STEM?

d) How can I reshape my course so students don't view diversity and inequity as issues outside of STEM?

These questions align with Sheth's work (2018) that proposes science teachers and teacher candidates "grapple" with racism as part of their foundation when learning to teach science. That grappling with racism is not an extra topic to cover in science education, but instead it is institutionalized as part of the professional responsibility of a science teacher. With regard to taking on this challenging work, I attempted to address these concerns in class last year and was unsuccessful. I used a tool focusing on their own identity and types of privilege that exist. Ultimately I think many students wrote what they thought I wanted to hear, while a few shared their frustration with the assignment. In retrospect, I realized that it may have felt threatening to their own identities and/or may have induced uncomfortableness.

Therefore, at Crossroads, I want to know how I can reshape my approach with my preservice teachers to address issues of diversity in a productive manner.

If we professionalize it, will they stay? Extending the reach of the higher education academic culture to the K-12 science teacher leader community

Greg Rushton, *Stony Brook University*

Context

In the preceding decade before starting my PhD program in 2001, I worked as a science teacher in two schools: one, a high-needs, mostly minority-serving high school in rural South Carolina; and the other, in a science magnet program in the more affluent suburbs.

Since finishing graduate school in 2004, I have been working as a chemistry faculty member in higher education where I teach chemistry and science education courses and conduct research in the areas of teacher professional development and teacher quality. I'm now at a research-intensive institution in New York where I work mostly with inservice teachers in a science education PhD program, but spent over a decade previously at a regional comprehensive in suburban Atlanta where I recruited, prepared, and (tried to) retain new teachers out of STEM fields. In all four positions (two in K-12, two in higher education) over those two decades, I have spent literally thousands of hours with other science teachers, and have decided there's two groups that are of particular interest to me — professionally and personally. The first is the one I identified (and still do) with most closely, which in today's vernacular might be labeled as 'master teacher' or 'teacher leader' (Katzenmeyer & Moller 2009; Wenner & Campbell 2016). They're the ones constantly seeking the next certification (e.g., National Board), the next endorsement (gifted, ELL, TESOL, administration, Advanced Placement, literacy), the next degree program (M.Ed., Ed.D., Ph.D.), and the next professional development conference or association to join (NSTA, AAPT, AACT, NABT). They talk all the time about school, students, administrators, parents...and their version of the venture/vexation conversation about teaching, learning, curriculum, assessment, technology, equity, diversity. Then there's the other group, which in many ways I perceive as the galactic opposite...seemingly never interested, and sometimes adversarial to, the newest Standards, technological advances, improved pedagogies, summer courses, or teacher accountability policies. These folks don't seem to want to stay late after school to tutor the needy students or plan a new laboratory activity; they don't want to participate in our professional learning communities or sign up for our university-sponsored professional development projects...they seemed to have suffered some form of 'burnout' (Hakanen, Bakker, and Schaufeli 2006; Chang 2009). Although these classifications are likely only caricatures of actual teacher profiles, they are useful constructs to consider for my venture/vexation.

Vexation

Although I have read and written in the literature on teacher quality and retention, directed or co-directed many projects intended to improve the local and national condition of science education, and thought as deeply as I can about these issues, one pervasive and vexing challenge remains to me unresolved. From my position in the system, I struggle with how to contribute to substantive change in the K12 community so that our best and brightest teachers can continue to persist and thrive over the course of a career rather than leave, move, or become disillusioned or burned-out. At the same time, I wrestle with mobilizing those on the opposite extreme, to either leave, move, or become re-energized. In simpler terms, I'm unsure how to keep our best from leaving (either literally or figuratively) and the worst from staying. This is a professional interest of mine since I am seeking to improve the access to, and quality of, science education in this country, and teachers for me are an essential consideration towards this goal. It's a personal one, too, as I am one of many that started in K12 and ended up leaving it early in my career in search of a position with the potential to influence the system in a way I could not (or could not see how to) in my role as a science teacher.

One of the reasons I find this issue so vexing is that I hear from almost everyone in my community of practice, from teachers to teacher educators to administrators to researchers, that there's no way to really accomplish this at the system level. I get the overwhelming impression that there's a consistent perception that this issue is intractable, and the reasons appear to be almost endless. In some of our teacher leadership work we have raised the issue of 'learned helplessness', where everyone agrees that the system is broken and there's nothing we or anyone else can do about it. It's not that there's a solution that's available and we just need to tell folks about it and mobilize/motivate them to embrace it. Instead, there's the perception that a solution does not exist and likely could not, either. At this point, I'm not sure if I should continue to focus my efforts in this direction or resign myself to working in the small space of those in K-12 that have found a way to make it work for them.

Venture

Over the past seven years, I've been working with some colleagues to produce a framework to develop science teacher leaders that leads to long-term growth and persistence while retaining some instructional responsibilities within the science classroom (Criswell et al. 2017; Rushton & Criswell 2015). Our research group is now poised to engage in a multi-institutional case study where we consider whether or not our leadership models contribute to teachers developing a leadership identity that's consistent with, or contrary to, a position as a classroom teacher while maintaining or growing their leadership opportunities (Little 1995; Berry, Byrd, & Wieder 2013). What we're trying to decide is if there's space in the conventional K-12 universe for enough 'hybrid' roles for those seeking them, or, alternatively, if there's a way to restructure schools so that they can (Peacock, 2014). My current thinking is that there either is, or should be, a way to do so. I'm looking to the Crossroads community to help refine and challenge my ideas about whether I'm right or not in what I believe and about the means to achieve my goal.

In most of our faculty roles in higher education, we have a workload model that includes teaching, scholarship/creative activity, and service. For those seeking an emphasis in one of these areas over another, there seems to be general consensus that the system can and should accommodate such aspirations. Indeed, whenever I've been wanting to lead a new program or write for funding in an area of research, my administrators have adjusted my duties to allow for such pursuits. For many teachers I've worked with in the K-12 arena, their workload models don't seem to be as flexible. But is that the way it really is, or just their perception of it? That is, does the system need to be seen differently (Goodwin, 1994), or does the system need to be reconceived so that it does support such efforts?

I think some other features of our higher education system should be considered as models for the K-12 one. I've learned some about the idea of shared governance, where faculty have a real voice in how the university is run, including budgetary decisions. We have a hiring system that relies on faculty disciplinary expertise and knowledge of the political, social, and programmatic culture to ensure that prospective colleagues will be a good fit for our departments, and we are expected to mentor, supervise, support and be otherwise invested in each other as a community. We contribute to decisions about long-term commitments to particular individuals through a tenure process, and we develop and self-police promotion documents to legitimize the advancement through faculty ranks. These cultural norms could go a long way towards transforming the K-12 career so that it is perceived by both the practitioners and their stakeholders (students, parents, administrators, community members) as something that looks like, and functions as, a profession (Tobias & Baffert, 2010). I want to know if these ideas are worth pursuing, and I look forward to having this conversation with you all this fall.

Questions I'd like the Crossroads community to discuss:

1. What models exist or could exist for ambitious and motivated teacher leaders (or those emerging as such) to find long-term satisfaction within the K-12 system while remaining teachers and growing in their leadership roles and influence?
2. If we can identify (or imagine) these models in practice, what changes to the current system must be made to facilitate their establishment at scale?
3. What specific, actionable steps can I take from my position in the system to positively affect those desired changes?

Troubling Testimonies

Stephany Santos, *University of Connecticut*

I begin in the spirit of #HipHopEd, a community of educators and scholars who challenge traditional educational systems to value the power of youth culture and voice. I start with a verse from the rapper J. Cole, followed by the connection to real quotes from students recollecting their educational experience.

And I'm in denial
And it don't take no x-ray to see right through my smile
All we wanna do is take the chains off
All we wanna do is break the chains off
All we wanna do is be free
All we wanna do is be free

-J. Cole, from the song "Be Free"

Denial (line 1)

"I was ill prepared for college. I thought college would be like high school"

"I denied that I needed help. That I needed my hand to be held a little bit tighter than my white peers. It's not that I needed to be babysat, but I needed someone to hold me accountable"

"It bothered me that my teachers didn't seem to give a fuck about me. I wish they cared if I showed up, or looked confused, or knew something else about me besides my name."

Seeing through my smile (line 2)

"It's not cool to look too smart. But it's not cool to be the one that can't read. So I just smile, and pray they don't call on me"

"I'm not afraid to cry, but you'll never catch me looking weak."

"What grade did you get? Oh, you failed too? Yeah, fuck this shit. We don't need this shit anyway"

Take the chains off (line 3)

"This school looks like a jail"

"After school, I'd run home to put my McDonald's uniform on, take a cab or ride my bike to work, then work until 9 PM. I got money for school supplies, and it also came in handy to get spending money for food on days we had away games, and the school didn't provide dinner. When I got home, I'd be too tired to do homework, but I did what I needed to do"

Break the chains off (line 4)

"My pastor says if you feel the spirit, let the spirit take control and run free. If you feel like dancing get up and dance. If you agree, rejoice. Don't bottle it up. Let it out"

"Doesn't professional development mean 'whitewash' development?"

Be free (line 5)

"As a minority, it's more important to be able to express your opinion, than it is to be right"

"I'm so well spoken isn't a compliment"

Be free (line 6)

"One more time for the people in the back"

Vexation

I was asked by university faculty and staff how to "increase diversity" in my department and at my institution. As an engineer, I decided to approach this question by probing the problems before identifying the solution, asking "why" before asking "how", and initiating what is called a "root-cause analysis". After several iterations of interrogating the problem, I found the biggest threat to a person is their sense of freedom. The biggest fear is feeling invisible.

Historically, we acknowledge that minorities were granted less freedom than their white counterparts. Research shows that the emotional trauma inflicted during slavery can become embedded in DNA and passed down through generations as Post-Traumatic Slave Syndrome (Leary & Robinson, 2005). Namely, the structures and systems that promoted the dehumanization of African Americans and other minorities contribute to the behaviors, actions, and beliefs harbored today (Sule, Sutton, Jones, Moore, Igbo, & Jones, 2017). In an education context, any component of the educational system that makes minority students feeling less human has an exponentially greater impact on their mindset than it does their white counterparts.

As shown in the student testimonies, there are components in the educational system that contribute to minority students feeling frustrated at school. This leads to lower graduation rates from high school and higher education. From an educational environment that looks and feels like a jail, to the sentiment of having to conform to white culture be accepted and seen in the professional world, our minority students are being stripped of their fundamental right to feel free. This freedom is a sentiment they are fighting for both in and out of the classroom. It can be emotionally exhausting when the majority of a person's day is dedicated to fighting to feel as a valid human being.

In engineering, future employers may ask: "What experience do you have?" Many minority students reply they don't have any, due to the necessary choice of working part-time for money rather than an internship for no pay. In this situation, potential employers will fail to acknowledge the experiences that comes from "creating something from nothing" — like a 'ghetto' or '*rascuache*' fix as an engineering experience. This is the outsider perception even though the elements of the design process are there, but never formally taught to label it that way. Society acknowledges a pianist that cannot read music as a great artist, or a street baller as a natural athlete. In contrast, we do not acknowledge our "MacGyvers from the Hood" as engineers. It ignores their personal experiences and excludes them from a standard definition of what it means to engineer a solution, as historically defined by our white founding fathers.

Venture

My venture began with listening to my students' struggles. From their testimonies, I created a course for underrepresented students in engineering titled "Confidence, Communication, and Presentation." In this course, I challenge the students to identify and delve into problems affecting their self-identified communities and empower them to share what they perceive to be a valid and valiant solution. In essence my hopes for this course are: (1) providing them a judgement free platform and a pedestal to sculpt their identities and reveal their decision-making core, and (2) developing an emotional shield and toolkit to be able to withstand sentiments such as *Imposter Syndrome*, which is prominent among my students. Although the students love the course, it should not take a one-credit elective to have students feel they belong in college, can identify as having the capacity to be successful engineers, and finally "be free." As a future professor, I aim to develop course content that that integrates culture and communication into the engineering world, and not as a separate domain or consideration.

Questions

1) How might I go about creating an educational ecosystem within my own teaching efforts that provide an ebb and flow of ideas within my classroom while also giving value the varied experiences brought to school by each and every student?
2) How might I prevent underrepresented students from feeling dehumanized amidst educational content that is engrained in the curriculum and derived from colonialist practices that do not acknowledge their culture's contributions to the past and present?
3) How might I remove the feeling of the classroom and the school being a jail, especially in a "travelling teacher" institution?
4) How might I infuse opportunities to build confidence and develop an emotional shield or toolkit to be able to withstand sentiments such as *Imposter Syndrome* in my science or engineering curriculum?
5) How might I shift what students perceive to be irrelevant or unprofessional, and their perception what it means to think like an engineer?

Belly to the Ground

Eleanor Sather, *DaVinci Academy of Science and the Arts*

Vexation

Engagement. This million dollar word in education is the source of much research, not to mention a multitude of Pinterest boards. We sound so sure when we toss the word around yet I do not believe that we all have the same picture in our minds about what an engaged student looks like.

When my son is chatting with his cousin and playing Rocket League online he is certainly focused and enjoying himself. Is this engagement? When a teacher is reading a book to the class, one they love and one read well, they listen with rapt attention. Is this engagement? When students have been coerced into silence, the entire class working, on task and quiet are they engaged? I would argue that while these children, in every example, are listening, are involved in the teacher or task in front of them they are not truly, organically engaged; too often everything from compliance to interest is confused as engagement.

Then what is organic engagement? To me, true organic engagement must involve the exploration of something personally significant to a child. You have seen this engagement many times, and so have I. I have watched as my toddling, tippy daughter knelt, then laid down, belly to the cement, as a worm inched its way across the sidewalk. I have held witness to my son as he casts endlessly in a half frozen river, catching not a thing yet going home to research better techniques for fishing, new flies to tie. I have stood stalk still in the merry chaos of my classroom and watched as a kindergarten student delicately balanced the final piece on a tower, only to have it come crashing down, then begin again, moving a piece here, a piece there, intent in that moment. Unfortunately, only one of these examples is from a classroom setting. There are many more like it, I hope that all teachers have examples, but these are too rare; self-lead engagement seen as the exception not the rule in a classroom setting where order and silence is rebranded as “engagement”.

What does it mean to have a truly, organically engaged student? To my mind, true engagement is found when humans are allowed to be humans: Curious, loud, thoughtful, quiet, messy, focused, scattered, planning, trying, failing, mulling, trying again. Humans are fundamentally curious beings. To this end, I believe that true engagement stems directly from a curiosity. What makes *me* curious is why, as a system, does science education seem intent on driving curiosity out of the classroom? What have we, as teachers, put ahead of curiosity--the gateway to true engagement? Classroom order, absorption of the materials, a simple to grade quiz, quiet students, benchmarks, obedience, standardized testing, to name a few.

Each teacher makes a daily choice, whether they intend to or not: Will I place a higher value on order and obedience or will exploration and curiosity rule the day? More often than not, order and obedience win out. But I do not think it’s fair to lay blame for this choice solely in the hands of teachers. As we all know, deeply and painfully, educators are asked to do more than is humanly possible. In a nation where we are being judged heavily, sometimes solely, on test performance, how can we expect teachers to lean into the messy, the questioning, the trying, the failing and the trying again? When student performance reports are based on a single test, educators should not be judged harshly for putting curiosity second, while ingestion of material comes first. There is no blame here, only a second personal curiosity of mine to be unearthed: In my current role of curriculum development and teacher support, how can my team and I best help teachers awake in their students’ true engagement in the sciences and beyond? How can we assist teachers in moving past tricks and tips that mimic engagement and toward true, deep engagement through an all-encompassing curiosity?

Venture

What I've come up with is a grain of an idea: That inquiry-driven learning, seen through the lens of the science and engineering processes, could help our team of teachers embrace curiosity in the name of organic, interest-centric engagement and learning. To get true engagement we need to inject wonder and curiosity into the classroom. To do so I am proposing a three-pronged solution: Weaving inquiry in as we build our science curriculum, making use of learning walks and implementing monthly roundtable discussions. These will work together by leading teachers toward trying more student-lead learning, sharing classrooms and examples of this type of learning and coming together as a teacher community to celebrate successes and ponder struggles.

The first prong is helping teachers weave inquiry and student-led learning into their curriculum. I have the great honor of working with each grade level team, kindergarten through sixth grade, to develop a customized, integrated science curriculum. We meet anywhere from once a week to once a month to build this curriculum together; it is a living, breathing document that can adapt to both teacher and student interest. The challenge, initially, is helping teachers embrace inquiry within their classrooms; to not just tell their students the answers, but to guide them in finding their own answers, especially to questions about the world that they have formulated themselves. If this is done well, students are introduced to a phenomenon—let's say a walk to the river as an introduction to the water cycle—where they are able to wonder, question, sketch their ideas and access their prior knowledge. From here, the curriculum should allow time, space and resources for students to explore whatever they wonder the most about the water, be that the water in the Ogden River, the clouds above or that which runs from their sinks. But this type of learning, and teaching, doesn't come naturally to everyone. Teacher concerns range from, "I don't have time to let them do this." to, "What about the very specific questions about the water cycle on the state test?" And here is where learning walks come in.

Our second prong would be learning walks. This technique centers on small groups of teachers visiting up to six classrooms in one session. These walks would be preempted with a focus, along with a form that allows for observations, wonders and speaks to a singular element in the classroom. For our purposes, the first learning walk element would be organic student engagement during an integrated science block. The principal would lead the brief before the walk, the walk itself, and a debriefing after the walk concludes. Here, observing teachers would answer questions based on their notes and discuss their wonders, observations and takeaways. All talk would be constructive, positive, with an emphasis on learning from one another. "Stealing" of ideas would be encouraged, as well as constructive wonders for the observed teachers. Both the observed and observers could benefit greatly from these walks. They would also be a great jumping point for the monthly roundtable discussions, the third prong.

The format of these discussions would be simple yet powerful: Each teacher is asked to share a celebration and a struggle for the month. Participants are invited to be vulnerable about their struggles and open in their successes. It is not a stretch to imagine information from the learning walks being a natural part of these discussions. Teacher struggles and celebrations may have been observed by a peer, or an observation from another room may be a helping hand in solving a struggle. When we focus our learning walks on organic student engagement this is bound to be a natural topic during the roundtable. Even after the roundtable is over, after the learning walks are complete, teachers will have a new focus to consider as we work together to plan their science units.

This holistic approach should help shift not only ideas about what engagement looks like, but what it means to be part of a team of teachers who support, care for and are invested in one another's success. It should lead to a school where on any given day, it's a rule, not an exception, to walk into the classrooms and find students truly, organically engaged, excited to share their work with the world. In this school, commonplace is that toddler on her belly, watching a worm for the first time, kind of engagement.

John Settlage, *University of Connecticut -- Avery Point*

Vexation

Just three months after starting coursework, preservice science teachers at Avery Point enter a full semester of student teaching. Each cohort is a mix of scientists undertaking career changes along with STEM majors who just graduated. Typically, any exposure to adolescents in science learning contexts has been brief and insubstantial. I frame the STEM Camps we've instituted as teacher development spaces where naive views of science teaching are displaced. The goal is for future science teachers to adopt fresh frameworks for positioning themselves within classrooms and in relation to subject matter and students.

Perhaps it isn't surprising for a UConn employee to employee coaching strategies (Mangin & Dunsmore, 2015 within teacher development. As the "head coach" with multiple university instructors and science teachers, we supply embedded feedback as lessons are prepared and delivered. I have paused lessons to request an improved explanation of lab procedures and because they are co-teaching, I will speak on the sidelines to those not on stage about adjustments that could or should be made. On occasion, we'll pull people out so they can observe other classrooms. Because STEM Camp has become so pivotal, we now run two each summer. Alums from previous cohorts will visit and remark about how differently they see themselves as a consequence of their STEM Camp experiences. This in turn prompted me to consider applying STEM Camps to in-service science teachers.

Using my connection with a science coach turned assistant principal, I attempted a weeklong STEM camp at her school this summer. The district paid union hourly rates to the 7 teachers who opted in. The school recruited kids and we ended up with 25 students, grades 3 through 5. I selected the units (from the Engineering is Elementary www.eie.org), purchased all necessary equipment, and spent all of a Monday talking about growth mindsets, funds of knowledge, concepts before vocabulary — and how to deliver the hands-on activities. Four teachers took to all of this was great enthusiasm and did an impressive job integrating their beliefs and skills with the new ideas and strategies. The other three did not. Instead, they'd cluster in a separate room to plan and applied others forms of resistance throughout the week.

I explained to the teachers at the outset how my preservice advisees benefited from STEM camps. This prompted unexpected advice about how I should be preparing teachers. When told that student teaching should be a full year (and that theories are "crap"), I counter saying I preferred to have preservice teachers in multiple settings because of uncertainties about where they will teach after graduating. Each day, I received added opinions about my profession and came to appreciate these gifts as a teacher version of "man-splaining." My ideas were countered by the teacher's experiences which trumped anything I offered. It didn't help that the speakers' exuded low expectations of students. On the last day, the main complaint was that my units were not on topics delivered by those teachers. When I asked the fourth-grade teachers what their science units were, they struggled to recall.

This raw experience has been incredibly revealing. The contrasts between the two types of STEM camps has been on my mind since mid-July. The sense I've made of this has been influenced by the notions of framing and positioning. In the preservice context, the framing has been relationship-building – among the educators, between teacher and students, and viewing the local circumstances as resources rather than impediments. The preservice STEM camps positioned everyone as valued, competent, and worthy of respect. When the morning teaching experiences are integrated with afternoon coursework about social foundations and teaching kids with exceptionalities, the science teachers develop rich perspectives about their budding careers that are more complex that they had anticipated. In contrast, the in-service STEM camp was framed as an outsider providing training. The associated positioning was Us vs. Not Us. Not only did this occur for teachers vs. me, but because the children attending STEM camp came from multiple schools and towns, they were also positioned – as Ours vs. Not Ours. This was all a reminder that every educational initiative is shaped by individuals and the perceptions about the sources of problems and the explanations for logical solutions.

Venture

In our accelerated science teacher preparatory program, anything added requires reducing other components. While I once enthralled by stories of programs with multiple science teaching methods courses, recently I've realized that our programs combination of experiences devoted to equity is a strength rather than a flaw. For too long, I've fooled myself into believing that science pedagogy and equity outlooks could be blended together. Sadly, I am unable to point to places where this actually occurs. The STEM Camps' differences pushed me to accept the need to prioritize. What will transpire after my advisees transition into science classrooms has been included in those deliberations.

This shift has taken far too long for me to recognize. I blame love: I've always loved science and became addicted to witnessing the processes supporting science learning. Being a science teacher was delightful; working to help others do the same was even better. I wanted to become equated with brilliant science pedagogy. Giving up this vision has been a struggle. When I recently read this quote from James Baldwin (1956, page 568), I understood what made this transition so tough:

> *Any real change implies the breakup of the world as one has always known it, the loss of all that gave one an identity, the end of safety. And at such a moment,* **unable to see and not daring to imagine what the future will now bring forth, one clings to what one knew***, or thought one knew; to what one possessed or dreamed that one possessed. Yet, it is* **only when a man is able***, without bitterness or self-pity,* **to surrender a dream he has long cherished or a privilege he has long possessed that he is set free** *– he has set himself free – for higher dreams, for greater privileges.*

My venture is to more explicitly promote equity as the central, defining feature of science teacher preparation. In this space, I use "equity" to signal a justice-centered stance toward schooling (Tolbert, Schindel & Rodriguez, 2018). This manifests as ongoing considerations of colorblindness, achievement gaps, social justice, White privilege, residential segregation, unintentional bias, and so on. No more apologies for having just one science methods class: It is just enough. Other places have only one class about multiculturalism and typically divorced from science pedagogy. I'm weary of passively positioning of equity — such as when a curriculum is equitable because it is open to all. Such assertions sound complicit with the status quo. We're going to replace this squishy equity with greater intentionality. Instead of "allow" we're going to instead "insist" students participate in science. Rather than "opening doors to science" the plan is to "provide leadership into science" as a central focus to an entire course.

Our school systems are horrible sites for advancing equity-oriented policies. Instead, most dutifully and powerfully replicate oppressive exclusion agendas. I feel okay about trusting schools to implement reform practices; universities are far better for disrupting racialized deficit ideologies among new teachers. To frame science teacher preparation as centrally concerned about equity, I am encouraged by Manali Sheth (2019) who suggests centering racism when contemplating: (a) students and their thinking, (b) individual and community connections to science, (c) STEM as a way of knowing and being.

If someone needs to explain why this can't work at their institution, I am instantly convinced. Without a belief such framing is possible, the endeavor is over before it starts. For those who might entertain the possibilities, I am soliciting your generous critiques. How might we support one another by seeing where framing will lead across various contexts? Should we be systematically communicating about courses, field experiences, and science teacher preparation programs? Ought we begin to plan staff development provided across sites? How can safe spaces be created that allow shared vulnerabilities regarding authentic commitments to a social justice agenda?

In closing, I confess I have the freedom and privilege to do this work. For my Venture, I'm looking for opportunities to connect with others – either to substantiate what is already underway in our program or to recruit others who could benefit from my hard-won lessons to promote similar efforts in other places.

Fully Informed vs. Overwhelmed: The Implications of Contextualized Epistemic Practices of Science and Engineering Education

Asli Sezen-Barrie, *University of Maine*

Scientific knowledge does not float free in some abstract, context-free domain, but is instead situated.
~ Charles Goodwin, 1995, p. 237

Charles Goodwin, an anthropologist, made this claim in his article “Seeing in Depth” where he analyzed how oceanographers constructed knowledge with the tools and norms of their discipline that become invisible across time to the members of the research vessel. Goodwin’s work and ideas from others, such as Kuhn’s *The Structure of Scientific Revolutions* (2012), have informed the way I represented science as a cultural-historical endeavor where scientific knowledge was constructed within a context where individuals participated in a shared activity and formed a culture. Within each activity system, members of the culture use specialized tools (discourse, representations, or materials) and create norms of practice (Engeström et al. 1999).

In order to convey the sociocultural knowledge construction to preservice and inservice teachers I worked with, I used examples of data, evidence, and methods of validating evidence from current scientific studies. These included looking at energy conversation with Newton’s Cradle, images of rock samples collected from Mars, and changing pollen counts over 12,000 years. These examples led to quite extensive discussions on how strong claims can be constructed from data that is not repeatedly observed in laboratory environments. In the interdisciplinary field of climate change, I have done work around contextualized epistemic practices of scientists such as temporal and spatial reasoning. These practices are crucial to claims that climate scientists make and it is important for the public, teachers and students to make sense of these practices in order to fully understand the science and be able to refute denial theories. In their ethnographic case study, Walsh and Tsurusaki (2018) saw that students who work with scientists and understand the temporality of climate data analysis come to agreement with the scientists even when their political affiliation is not supportive of human impact on changing climate. Moreover, these distinct practices can help students understand why scientists can have disagreements, counterclaims, and can be responsive to changes (Sezen-Barrie, 2018).

Vexations

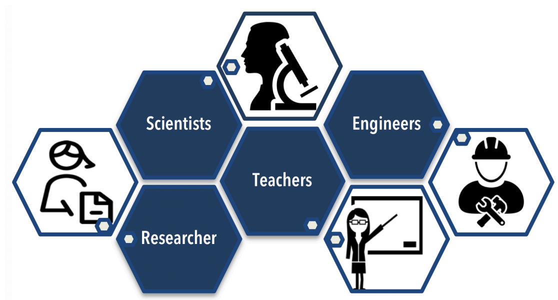
Assuming we agree that knowledge is not constructed in a context-free domain (Goodwin, 1995) and that understanding of data validity can differ depending on your discipline and even within your project group, how can we use these ideas in K-12 classrooms without confusing students, teachers or decreasing the value of the deliberate scientific process. Eight scientific practices in the Framework (2012) and the Next Generation Science Standards provide a useful framework for teachers, however they don’t really provide distinct practices of various scientific disciplines (Cunningham & Kelly, 2017; Sezen-Barrie, 2018). To add to the problem, NGSS has even less clarity when applied to engineering practices, as I have found discussing this topic with engineers. (Cunningham & Carlsen, 2014). Despite the obvious need for elaboration of these practices, the differences among scientists’ and engineers’ cultures are also quite different than classroom cultures (Ford & Wargo, 2007). Therefore, my vexations are around the dilemma of informing students about the multiple ways of doing science and engineering without overwhelming teachers with too many variations; especially at under-resourced schools.

Ventures

In an attempt to answer my question of how can teachers be fully informed but not overwhelmed as they are learning and teaching scientific practices, I am working on the accessibility of the tools and representational means of contextualized epistemic practices for classroom environments. I foresee two lines of research to help achieve this goal:

1. **Study the Interdisciplinary Design Team.**

   Interdisciplinary research projects on education bring together people from different disciplines such as sciences, engineering fields, educational science education to work towards a shared goal and often had practical applications for classrooms. Each member of the project team comes with their background and experiences from the other subcultures they belong to (Erickson, 2016). This multiplicity of ideas leads to *rich points (*Agar, 1995), i.e., the times of interaction that idea clashes between members of the project team occur. During these moments, project team members engage into prolonged conversations to negotiate and settle on meanings or ideas. I have already started and I plan to continue keeping records of design team meetings as possible sources of data. These records of information can be video records of meetings with interdisciplinary members of team, written reflections, and email exchanges. By looking at the discourses of these interactions from an interactional ethnography point of view (Baker & Green, 2007), I aim to identify the ideas scientists, engineers and educators negotiated on. My current study shows that design team discussions and reflections impact the ways that teachers make decisions about what epistemic practices they highlight during classroom implementations. Studying such cases in depth might help figure out how scientists, engineers, researchers ideas intersects with teachers in integrating distinct epistemic practices in classroom.

2. **Ethnographic Interviews and Observations of Engineers' Work.**

   My plan as an educational researcher is to have a more complete sense of engineering process by immersing myself in the work of engineers from different disciplines and companies. My goal is to understand the invisible rules engineers establish to construct an innovative product, what knowledge base they derive from, and the examples of tools that engineers use to navigate their failures. Cunningham & Kelly (2017) enhanced our view of the engineering process by identifying practices for educators by reviewing seminal books engineering professionals. My plan is to take this to an empirical step to see how engineers highlight the important aspects of engineering.

As I am walking the initial steps of these two adventures, I would like to discuss the following questions with colleagues at Crossroads:

1) How can our own work within interdisciplinary project teams can help inform with integrating contextualized epistemic practices to classroom activity?
2) How can findings from ethnographic studies of engineers' help enhance engineering education activities that are commonly used in the schools and related professional learning for teachers?

Expanding Socio-Environmental Perspectives: An Ecological Worldview Conceptual Framework

Teresa Shume, *North Dakota State University*

Vexation

Complex environmental problems that arise at the interface between natural and human systems such as global climate change, loss of biodiversity, and ocean acidification – to name a few – are sometimes called "wicked" problems because they are characterized by multiple uncertainties and compounding risks that often expose sharp disagreements in values and beliefs (Balint, Stewart, Desai, & Walters, 2011). The causes for such environmental problems are never simple because they typically emerge from complex socio-environmental systems, and invariably span across a wide range of scientific, economic, political, cultural, moral, and epistemological domains. Similarly, problem-solving efforts seeking to protect or restore resilience in socio-environmental systems also necessitate multiple types of boundary crossings, and a capacity to straddle boundaries between diverse perspectives that may be rooted in deep incongruences (Bammer, 2013).

For example, the reintroduction of wolves into the greater Yellowstone ecosystem in the mid-nineties sparked vociferous public debate and protracted legal battles about wildlife management policies and practices, including how to handle depredation of livestock and whether to permit wolf hunting in particular regions once wolf populations were restored to certain levels (Schullery, 2003). Wolf management practices in the greater Yellowstone ecosystem and other regions, such as the Upper Midwest, continue to impact a wide array of stakeholders, including indigenous groups, farmers, ranchers, wildlife scientists, hunters, trappers, outdoor enthusiasts, wildlife advocates, and many more. Beliefs and values about wolves vary widely, deeply, and sometimes sharply across various stakeholders. For example, differences in epistemological, axiological, and ontological commitments may underpin conflicts about issues such as what "counts" as evidence or how to evaluate risk, as well as the role of evidence and risk in collective decision-making. Yet input from multiple stakeholders is crucial for developing workable solutions to thorny problems about wolf-and-human interactions.

Given the imperiled ecological state of our planet, it is imperative that we equip our students with the kinds of skills and dispositions necessary to grapple with complex socio-environmental problems. This is the principal reason why much of my teaching and research over the years has lived at the nexus of science education and environmental education. Indeed, when I was a high school science teacher and a college biology instructor, I regularly invited students to wade into the messy places where traditional Western science alone could not provide sufficient answers to environmental problems. The use of case studies, role plays, book discussions, jigsaw readings, and other reflexive learning activities made some spaces to include perspectives that challenged the reductionist, anthropocentric, and capitalist ideological assumptions that typically underpin science curriculum in high school and undergraduate biology education. Yet I also felt moored to course and program learning outcomes that focused primarily on biology concepts and science process skills. Exploring voices beyond the traditional ideological underpinnings of biology curriculum has always felt to me like an "add-on" to regular curriculum, and thus the organization of the curriculum conveys a tacit message to students that that reductionist, anthropocentric, capitalist ideologies imbued in mainstream biological science remains the benchmark against which alternate perspectives are "othered."

I have long experienced a profound tension between a sense of obligation for fidelity to conventional science curriculum that speaks loudly in a rational and "common sense" voice, and a sense of commitment to advocating for the diversity of voices that extend beyond mechanistic and reductionist science as the only valid way of knowing. I want students to know and understand the value of science as a human enterprise that can stand alongside literature, philosophy, and art as ways that we know and interact with the world. I want students to be able to draw on scientific ways of knowing when formulating their own perspectives about environmental problems. Yet I also want them to know the limitations and blind spots inherent in science as way of knowing. I want them to engage in understanding and empathy toward socio-environmental perspectives that are not ensconced scientific ways of knowing or may be very different than their own.

I have experienced a similar type of tension in my research. For example, some years ago I presented research about anthropocentric bias in science curriculum materials at a professional science education conference. Perhaps I had chosen the wrong venue to share my work because my presentation was met with thundering silence and a lot of uncomfortable looks. Similarly, I can recall a senior colleague encouraging me to set aside my work on discourse analysis of mainstream environmental education curriculum after receiving a rejection to present at a national conference. Since then, however, I have found some spaces and research communities that challenge the dominance of traditional Western science within the context of science education and science teacher education. I currently have fledgling lines of research seeking to diffuse [or defuse??] this tension. I say more in my Venture about one of them. Sometimes, however, bodies of research in science education that challenge the dominance of traditional Western science can become unmoored from the daily realities faced by K-12 schools and classroom teachers. This is another type of tension of which I am acutely aware.

When teaching secondary or undergraduate biology, I have managed to stretch the curriculum to make some space for alternative voices that express perspectives that extend the range of epistemological, axiological, and ontological commitments regarded as feasible and legitimate in classroom discussions. I have never felt entirely satisfied, however, with the ranges I have achieved within the scope of my own teaching, nor do I feel that my research has dug sufficiently into this area. With the ultimate goal of equipping students with a constellation of sophisticated skills and dispositions needed to undertake complex socio-environmental problem-solving, I want to engage in research and teaching that contextualizes Western science ways of knowing alongside a range of voices and perspectives about socio-environmental issues.

Expanding Socio-Environmental Perspectives: An Ecological Worldview Conceptual Framework

Teresa Shume, *North Dakota State University*

Venture

At my prior institution, Minnesota State University Moorhead (MSUM), I used to teach a general education undergraduate biology course that was required in the elementary education program. Through participation in a workshop conducted at the National Center for Socio-Environmental Research in Annapolis, MD, I worked with a team of MSUM faculty members from four different departments to develop an instructional case study about wolf hunting in Minnesota. I used this case study multiple times in my general education biology course.

The case study centers on wolf hunting in Minnesota, and invites students to engage in a jigsaw instructional model to investigate concerns and issues raised by four stakeholder groups: farmers and ranchers, indigenous groups, hunters and trappers, and wildlife advocates. Students first individually research the range of perspectives belonging to one of the four stakeholder groups, then share their findings with others who researched the same stakeholder group. Next, mixed teams are formed by grouping four team members, each of whom researched a different stakeholder group. The mixed teams are tasked with critiquing the Minnesota Department of Natural Resources Wolf Management Plan and making recommendations about whether to eliminate, maintain, or change state wolf hunting practices. While teaching with this case study, I became increasingly interested in students' ideas about human relationships with nature, which ultimately lead me on a journey to explore ecological worldviews. Eventually, this work culminated in the development of the following ecological worldview conceptual framework (Shume, 2017), adapted from Wals and Bawden's conceptual framework for worldviews related to sustainable agriculture (2000), part of the Hawkesbury Critical Learning Systems model (Bawden 2000).

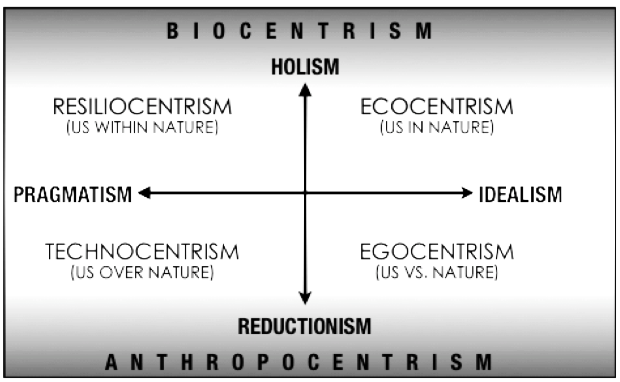


Figure 1. An Ecological Worldview Conceptual Framework

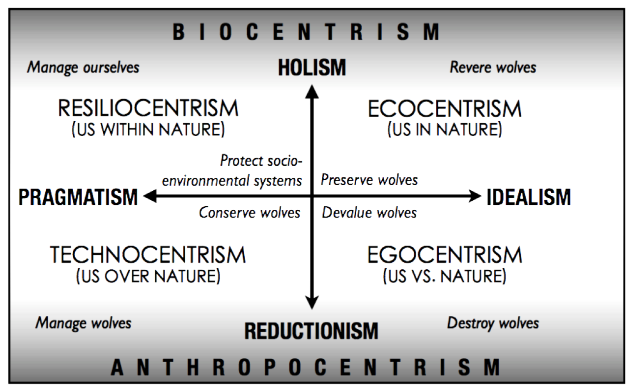


Figure 2. Various Responses to Wolf Hunting

This ecological worldview conceptual framework is comprised of four dimensions that can all be part of a person's ecological worldview: egocentrism (Us vs. Nature), technocentrism (Us over Nature), ecocentrism (Us in Nature), and resiliocentrism (Us within Nature). These dimensions are formed by intersections of three axes: an ontological axis focused on perceptions of nature as a system, ranging from reductionism to holism; an epistemological axis focused on the nature of knowledge most highly valued for seeking solutions to controversial socio-environmental issues, ranging from pragmatism to idealism; and an axiological continuum focused on value judgments about nature's ethical and aesthetic worth, ranging from anthropocentrism to biocentrism. To help clarify the framework's organization, various responses to the dilemma of wolf hunting are broadly mapped onto the framework in Figure 2. It should be noted that I expect this framework will evolve through research that involves its use.

I would like to engage the Crossroads community at this meeting to explore ways to leverage this conceptual framework to conduct research into pedagogy and/or curriculum that develop skills and dispositions needed to undertake socio-environmental problem-solving, with a particular emphasis on secondary or post-secondary learners': sophistication of thinking about complex systems, capacity for perspective-taking, empathy and understanding of perspectives different than their own, tolerance for uncertainty and contradiction, and reflection on their own ecological worldviews. Possibilities I am considering include developing an interview protocol and a Likert-scale survey based on the ontological, epistemological, and axiological constructs of the framework, and adapting the framework into a curriculum evaluation tool to gauge the breadth of ontological, epistemological, and axiological continuums represented or not represented in science curriculum materials. I am open to other ideas too.

- How might this conceptual framework be leveraged to conduct research into pedagogy and/or curriculum that develop skills and dispositions needed for socio-environmental problem-solving?
- How can science educators teaching about socio-environmental systems within the scope of secondary or undergraduate science curriculum contend with the epistemological privilege accorded to Western science?
- Where can I find professional communities with similar research and teaching interests?

Practices, Crosscutting Concepts, and Core Ideas: Could less be more?

Leigh Smith, *Brigham Young University*

Vexation

The publication of *A Framework for K-12 Science Education* (NRC, 2012) and *Next Generation Science Standards* (NGSS Lead States, 2013) has prompted discussion of both opportunities and challenges for K-12 science education introduced by the new standards (Stage et al., 2013). In general, the opportunities described in the literature emphasize what happens in classrooms and are connected to learning goals. They include (a) focusing on a limited set of core concepts in order to develop deeper understanding, (b) using the practices to apply this understanding in new and unique situations, (c) connecting important ideas across all science disciplines, and (d) applying an understanding of science content in solving problems or improving situations (Krajcik et al., 2014; Pruitt, 2014). The argument is that these opportunities will enable "all students [to] graduate from high school with the knowledge and skills…[for] college, careers, and life" (Achieve, 2015).

In contrast, the potential challenges in implementing the standards are wide-ranging because they, like those of previous reform efforts (e.g., AAAS, 1990; NRC, 1996), "represent a significant departure from past approaches to science education" (Bybee, 2014, p. 213). As a result, their adoption and enactment influences and is influenced by individuals and groups at national, state, local, and classroom levels, in addition to those at colleges and universities (Bybee, 2014). Thus, conceivable challenges include instructional hurdles, but also move beyond the classroom. Some of these include (a) evaluating and adopting the standards, which is determined at the state or local level; (b) building community and educator awareness of the goals and specifics of reform (Krajcik et al., 2014; Pruitt, 2014); (c) developing quality instructional materials and interventions, including preservice teacher preparation and ongoing professional development (Debarger et al., 2013; Pruitt, 2014); (d) designing appropriate formative and summative assessments (Gorin & Mislevy, 2013; Wysession, 2013), (e) providing students with opportunities and resources to develop the language and discursive skills requisite to negotiating abstract and diverse types of text so all students are able to learn and achieve in science (Hakuta et al., 2013; Lee et al., 2014; Stage et al., 2013), and (f) developing the depth of science knowledge required of both teachers and students, which is "a much deeper understanding of the phenomena as opposed to the memorization of the vocabulary alone" (Pruitt, 2014, p. 154; Bybee, 2014).

Much of the conversation surrounding the rollout of NGSS since publication has focused on professional development for practicing teachers (e.g., Duschl & Bybee, 2014). However, as a K-6 science teacher educator, a large majority of my time with undergraduate students is devoted to preparing *prospective* elementary teachers to engage young children in learning science. Thus, while I highly value the exciting and authentic opportunities for science teaching and learning introduced in the Framework and NGSS, I also recognize the potential challenges associated with adequately preparing prospective teachers to be able to enact them. As Bae (2017) so aptly noted, teacher educators play an important role in the implementation of science education reform, even as they work to develop their own understanding of new standards. As a result, I have struggled to determine what I might realistically expect preservice elementary teachers to digest and embrace in a 3 semester-hour science methods course.

The following are questions that led to my venture:

- How might I negotiate the inherent challenges and make the most of the potential opportunities of preparing prospective elementary teachers to (a) capitalize on positive past experiences with science and/or overcome their aversions to and fears of science, (b) believe that teaching science to young children is important and that children have the ability to think and reason scientifically, (c) recognize their responsibility to understand the science concepts they are responsible for teaching, (d) accept that teaching science is not the same as merely facilitating fun or engaging activities, and (e) introduce them to the three dimensions (i.e., what they are, how they work together, and what this "ambitious and complicated" [Lederman & Lederman, 2014, p. 141] and "revolutionary" [Wysession, 2013, p. 17] instruction might look like in a classroom of 30 5-year-old, 8-year-old, or 11-year-old children)? In short, what is reasonable to expect preservice elementary teachers to learn about teaching science in this new era of NGSS?
- Recognizing that quite often the 19th century proverbial phrase, "less is more," can be applied quite accurately beyond the original reference to good artistic design, what might be the "less" in preparing elementary teachers that is "more" beneficial to their learning as they prepare to teach children?

Venture

Context: Brigham Young University is a private university located in Utah, although the undergraduate student population of 33,000+ is split among all 50 states and over 40 countries, with only 30% of students residing in Utah prior to enrolling. Thus, unlike many state colleges and universities, whose populations are often dominated by in-state residents, many of our preservice teachers plan to return to their home states/countries to teach. Although students graduate with licensure to teach in Utah, 45 states grant reciprocity.

Venture: My efforts (to date) in addressing my vexation have resulted in structuring the elementary science methods course into four interdependent units of varying lengths: (a) Who am I as a teacher of science? (b) What is science and why should I teach it? (c) When I teach science, what do I teach? and (d) How do children learn science and what does that mean to me as a teacher? The first focuses on preservice teachers' science identities, which we continue to develop throughout the course. The second and third emphasize science as a body of knowledge, an important and useful set of practices, a way of knowing that differs from other ways of knowing, and a creative and important human endeavor. Here the students are introduced to standards (local and national), including the three dimensions, and are actively engaged in "doing science" as learners. The last unit (a majority of the course) actively engages students as learners and as teachers of science as they continue to experience, then plan and teach science to each other and to children in elementary classrooms.

Threaded throughout all units, the following instructional decisions regarding methods/strategies are used:

What taught. Most elementary schools in Utah include grades K-6. However, different *Core Standards for Science* are in place for grades K-2 (2010), 3-5 (2002), and 6-8 (informed by NGSS; 2015), each of which guide curriculum and instruction for designated grade bands. As a result, in our methods courses we have determined to simplify (i.e., less is more) by using the outlined science topics and concepts in these state standards as the science content framework for our course. Thus, recognizing that our course is a methods course, not a science content course requiring a heavy emphasis on teaching science concepts, all learning activities we use as we teach our students instructional methods and strategies, unit planning, lesson planning, assessment, etc. are directly linked to the content found in the state Core. Fortunately, these science ideas do not differ dramatically by grade level from the *disciplinary core ideas.* In fact, we have found the *Framework* (NRC, 2012) and the *Matrix for K-12 Progressions of Disciplinary Core Ideas in NGSS* (Achieve, 2013; NSTA, 2013) to be helpful to us and our students in fleshing out the science ideas represented in the state Core and determining developmentally appropriate science concepts as they develop unit outlines and lesson plans for children in different grade levels.

How taught and assessed. We have also determined to use the *scientific and engineering practices* as a way of organizing our instruction, focusing primarily, but not exclusively, on the science side of these practices (again, less is more). Beginning the first day of class, our students experience these practices as learners, as we model whole or partial investigations, deconstructing them during or after the lesson/learning activity to help students conceptualize what the practices might look like from a teachers' perspective. Understanding the practices also helps our students more fully appreciate the ability of children to reason and to make sense of the world rather than simply memorizing facts or participating in "fun" activities during science instruction, which is what they often observe during their field experiences. We find they are also better able to plan and facilitate meaningful science investigations during their practicum. Finally, we have found a useful textbook that offers additional classroom scenarios at different grade levels (see Schwarz et al., 2017).

Still unsatisfied. Although we introduce the crosscutting concepts, explaining their important purpose as we discuss standards, and modeling how they might be included as part of investigations, I am less satisfied with how well our students seem to understand them. In fact, although we ask students to identify appropriate CCCs for the instructional units and lessons they plan, this is the dimension that receives the least attention in our course. Moreover, we are unsure as to how to place more emphasis on them. Interestingly and unfortunately, the extant literature seems to address this dimension less often than the others as well. It is this part of my venture, in particular, that I hope to have help from Crossroads colleagues.

Jonté C. Taylor (aka JT), *Pennsylvania State University*

Vexation

Since the dawn of formal education, subjects have been taught as individual subjects. Subjects, teachers, and even learning theories are associated with individually siloed educational areas. This has been especially pervasive in K-12 education. Over the course of the past decade, there has been a shift in this educational practice. Increased emphasis has been placed on integrating educational area, almost to the point of acronymic absurdity. Science, technology, engineering, and math; better known as STEM, is now used with such frequency it can almost be considered the "sexy" acronym of the moment. STEM has now become so ubiquitous that we are incorporating more things into it. Many now add an addition "A" to represent the Arts making STEM into STEAM. Some have added an "R", and depending on who you ask, the "R" is either for robotics or reading making STEAM into STREAM. If this course keeps up, eventually someone will create STREAMSS (science, technology, reading, engineering, the arts, mathematics, and social studies). Despite all of the acronymic additions, the point is that the subject areas are intertwined and should be taught that way so learners better understand the interconnectedness of the world at-large; thus, removing educational silos based on instructional disciplines. In the pursuit of eliminating educational silos, many theories, ideas, schools, and suggestions have been enacted. The true meaning, purposes, and success of STEM initiatives can be debated. However, the true spirit of STEM is interdisciplinary education. Interestingly that spirit of interdisciplinary education rarely systematically extends to the discipline of special education and working the students with exceptionalities.

Students with exceptionalities are more likely to be in general science classrooms. According to the United States Department of Education Office of Special Education Programs (2015), over 60% of students with exceptionalities spend 80% of their instructional time in general education classrooms. Those numbers suggest that there is a high probability that science teachers will have students receiving special education services in their classes. Unfortunately, Kahn and Lewis (2013) report that: (a) one-third of science teachers feel unprepared to work with students with disabilities due to lack of training and (b) a majority of the teachers who have training describe it as "one-the-job. This problem is not exclusive to science educators. Special education teachers spend negligible amounts of time teaching science content.

So why is this important? As the data suggest, students with exceptionalities WILL be in the general education STEM classrooms at both the elementary and secondary levels. From personal experience, I can attest to questions that I have gotten from STEM educators regarding students with disabilities in their classrooms. Questions such as:

- Why should these students be in my classroom if they are so academically behind in reading and math?
- What can students with severe disabilities learn in my class with so many significant issues?
- How much more time will it take me to teaching with students with disabilities in my classroom?

While these questions and concerns should not be dismissed, the fact that these questions exist presume a level of disconnect between science teaching and learning and outcomes for students with disabilities. The "science for all" movement was meant to address the issues related to underrepresented groups and their access to and outcomes in science. This includes students with exceptionalities no matter the severity. Specifically, students identified with specific learning disabilities, being gifted and talented, or with "high functioning" Autism Spectrum Disorder have been the students mostly included in STEM classrooms while students with severe intellectual disabilities and behavioral challenges are not. From a position of equality and socially just pedagogy, all students should have the opportunity to learn science and learn in science-based environments regardless of ability. This lack of preparation to teach science to students with exceptionalities can be traced back to training programs.

The lack of preparation to work with students with exceptionalities starts at the preservice teacher level. General education teachers report that they take an average of 1.5 courses that focus on inclusion or students with disabilities while in their teacher training programs (Cameron & Cook, 2007). This is woefully minimal, particularly when compared with the increasing numbers of students with exceptionalities being included in general education classrooms. Special education training programs do not fare better as most special education preservice teaching programs spend little time on science and science instruction for students with disabilities. Further exacerbating the situation is the fact that many preservice teacher training programs are providing interdisciplinary STEM options in secondary education. Whether as residential or online certification programs, the options for interdisciplinary STEM education continues to grow. Unfortunately, as interdisciplinary STEM programs expand, there seems to be only perfunctory attention paid to students with exceptionalities and designing preservice programs with those students in mind. In essence, two silos still exist, science education and special education.

Venture

As a former special educator, I can attest that I: (a) had no training or experiences in teaching science, (b) was never asked or encouraged to teach science, and (c) taught science poorly when I did venture to teach science. For most educators (and researchers for that matter) looking for guidance on navigating the intersection of science teaching and students with exceptionalities, the most cited works have come from the 90's and include two researchers (Mastropieri & Scruggs, 1992; Scruggs, Mastropieri, Bakken, & Brigham, 1993). Along with those publications and unbeknownst to most, there has been research and institutions examining the intersection of science education and students with exceptionalities including: NSTA's Special Needs Advisory Group and an NSTA associated group called Science Education for Students with Disabilities (SESD, founded in the 1970s). Additionally, I have had to the opportunity to co-author publications have focused on analysis of effective interventions for students with learning disabilities (Therrien, Taylor, Hosp, Kaledenberg, & Gorsh, 2011) and emotional/behavioral disorders (Therrien, Taylor, Watt, Kaldenberg, 2014); the effectiveness of inquiry-based instruction for students with disabilities (Rizzo & Taylor, 2016). My other publications related to science instruction and students with disabilities have been more specific, focusing on outcomes related to the use of an argument-based inquiry approach called the Science Writing Heuristic (Taylor et al., 2012; Taylor et al., 2018).

The research I have been able to participate in has informed my instruction of pre-service teachers when it comes to including students with disabilities in STEM teaching and learning. Thanks to a number of student-initiated conversations, it became clear to me that I and special education in general was missing boat in teaching science. I have even found myself working outside of my silo (special education) and working with some great science educators and science teachers. I quickly realized that these great science teachers had many questions about working with students with exceptionalities. Most of them were good intentioned, but revealed they were clearly unprepared to provide the appropriate supports, accommodations, or strategies needed by students with special needs.

As a university faculty member in a special education preservice training program, I have attempted to find opportunities to investigate through research what works in science for students with disabilities. Beyond that, I have diligently worked on ways to provide supports to preservice teachers in teaching science to students with disabilities. For preservice special education teachers, I was able to work with my colleagues to revise a methods course in our Master's program that now focuses on STEM. Working outside my silo, I have been lucky to work with a colleague in science education (Scott McDonald) to provide experiential support in a science education methods course.

While these are first steps in my venture. In moving forward, I'd like to provide more and better supports in a more systematic way for preservice teachers in science and special education. With that being said:

1. How do we provide more authentic opportunities for preservice an in-service teachers to include students with exceptionalities?
2. How do we find the happy medium for what most would consider diametrically opposed theoretical frameworks?
3. What resources should be considered to get collaborative opportunities to occur at the preservice teacher and in-service teacher levels between science and special education?

Challenges of Professional Learning in NGSS-Averse Environments

Julianne A. Wenner, *Boise State University*

Vexation

Science education is not a priority in Idaho. Shocking, I know. And perhaps you're even thinking, "So? It's not a priority in most places." This is probably true. Nonetheless, as someone who loves Idaho, has chosen to make this state home for my family, and as a science educator, I find this issue incredibly troubling and fraught with complexities.

In the short three years that I have been in Boise, I have worked with several elementary teachers, both in the city of Boise and out in rural areas, and it is incredibly rare to find science being taught at the elementary level. And although I was unable to find any statistics to the point, I would venture to guess that science is often omitted at the elementary level across the state. When I *have* observed science being taught, it is frequently turned into an arts and crafts lesson because most elementary schools in Idaho do not have separate art teachers/classes; classroom teachers are tasked with teaching art. My colleague, Dr. Sara Hagenah, has worked with several junior high and high school teachers, both urban and rural, and has found that science education at the secondary level typically consists of lecturing, notes, worksheets, and occasional cookbook labs. When I approach both pre-service and in-service elementary teachers about teaching science, I am often told that there is no time or resources to teach science because math, reading, and writing are high priorities and scheduled for massive blocks of time with relatively rigid curricula. Both Sara and I have been told by teachers that there is definitely no time to teach science in a manner consistent with the NGSS (read: inquiry-based), and that they are often even afraid to teach science.

Figure 1. Idaho…because no one ever knows where it is.

Before I continue with this vexation, allow me to digress for a quick orientation to the culture of Idaho (see Fig. 1). It is a really, *really* conservative Christian state. That's not meant to knock conservatives or Christians, but the way this plays out in Idaho is that people *love* to talk about local control, so they don't want anyone 'telling them what to do', they largely believe people should keep their money in their pockets and not fund public goods (we're ranked 50th in per pupil education spending), and they see many science topics to be at odds with their beliefs (e.g. anything related to evolution, climate change, human impact on the earth, etc.). This year, we passed new NGSS-aligned science standards in the state (yay!), but not after a huge hullabaloo that resulted in an appalling rewrite of standards related to human impact on the earth. One of the most striking comments during this time came from Rep. Scott Syme (R-Caldwell): "I don't care if the students come up with a conclusion that the earth is flat – as long as it's their conclusion, not something that's told to them." Additionally, other state representatives a) shared that they did not believe new species were currently forming; b) revealed that they are informed about climate science by Rush Limbaugh; and c) described climate science as "ridiculous nonsense" that should be eliminated from all instructional content in Idaho.

Because we believe the need is so great for science PD in this state, both Sara and I have been offering PD at various schools in Idaho. Over the past two years, we have worked together with one elementary school that is 4 ½ hours away in a rural district; we are touch with them at least every two weeks and travel there approximately every other month. We have tried to do all the 'good things' one is supposed to do when offering PD: focusing on content, promoting active learning, connecting to their goals/standards/colleagues, extended duration, a high number of contact hours, etc. (Garet et al., 2001). However, we are skeptical of the impact it has actually had on the practices of the teachers and student learning.

When we first met this group of teachers, they did not teach science (unless it was after testing time for the year and it was 'for fun') and had not heard of the NGSS or NSTA. We began by asking them what they wanted science/STEM to look like in their school and talking through the NGSS and the practices. They latched on to the practice of engaging in argument from evidence, as they saw it as something they could do across content areas. From there, we have tried to open up practice, video and reflect on teaching, examine artifacts of student learning, and read together about how to support student ideas. Sadly, this has been an uphill battle, with even the most driven and STEM-passionate teachers going through the motions of our 'assignments' and work together. As a group, they have made very small and superficial changes to their practices over these two years, citing time, curriculum, pupil, and resource constraints. Many of the teachers are having students argue from evidence in other subjects (e.g. literacy) and calling it science – science content or the *doing* of science is sporadic. I share this with you so as to provide an example of what we would likely encounter with other elementary teachers across the state.

This then leads me to my vexation. Given the pretty intensive time/monetary commitment on our end combined with the questionable outcomes of the PD, Sara and I are pondering how we might thoughtfully craft our new PD venture, *STEM Learning Labs PD*. Specifically,

> ***Given the unique context of Idaho, what is the most efficient/effective way to work with (rural) teachers to promote high quality science instruction in the K-12 setting?***

Venture

Sara and I have already begun marketing our *STEM Learning Labs PD* in response to school districts scrambling to learn more about the new state science standards. The most immediate need from these districts is to learn about the standards and think about how they can be true to the shifts in these standards (e.g. more inquiry-based, student-led, three-dimensional learning, etc.) while being mindful of all that is on teachers' plates (e.g. teaching other subjects, testing, school initiatives, etc.). We are responding to these immediate needs, but also wish to form relationships with teachers and schools over time (rather than one-off PD), work on building capacity in science teacher leaders, and have a larger presence in the rural districts (72% of all districts in the state are rural) that are often overlooked by the three research universities in the state due to distance. At the same time, we are pre-tenure and cannot spend all of our time doing PD, even if we build a research agenda around it.

In sum, we are both committed to supporting Idaho teachers in teaching high quality science, but are not quite sure what this should look like. I am hoping that Crossroads participants can help me think through the following big questions:

> <u>How can we do job-embedded PD well at a distance</u>? We both strongly believe in the concept of job-embedded PD and all that entails, including building relationships with teachers, meeting them where they are, and understanding the systems that press on teachers' practice. It is 12 ½ hours driving from N-S in Idaho and 5 ½ hours from W-E, so physically travelling to schools would be a full-time job. How can we tackle this meaningful form of PD at a distance? What technology platforms or other models should we consider?
>
> <u>What is the 'correct' progression for our PD work</u>? When we began working with our rural district, they had never heard of the NGSS, the nature of science, scientific practices, etc. Most teachers did not teach science. When going into a secondary science classroom, we see notes, PPTs, and lecture. What should be our starting point? What are the intermediate steps? What might 'success' look like? What might should be similar/different between elementary and secondary work?
>
> <u>How do we respectfully work to shift beliefs about science education</u>? Conservative and Christian values (think *Educated* by Westover [2018] as an extreme version of this), generational poverty, and largely blue collar and agricultural economies all inform how science is valued (or not) in Idaho. Shifting teacher, student, and community beliefs seems to be a key component of what our work must include if we want to fundamentally reform science education and move towards best practices in Idaho schools. But this is a delicate thing. What might allow us to gain buy-in from the communities and schools in which we will work? The state STEM Action Center has taken the stance of promoting STEM for the sake of careers and revenue. However, I'm unsure whether this is a compelling argument to all – particularly those in rural communities. Being responsive to communities is particularly important to us because we don't want to 'lure' kids away from their families, further deplete already struggling local economies, or devalue blue collar and/or local knowledge and ways of life. How can we *work with* communities?
>
> <u>What funding could be sought out</u>? Given the attitudes towards science education in the state, many districts will not spend their PD money on science PD. Therefore, for districts who might want support but cannot pay for it, what funding sources might we consider (aside from NSF)?

i.hate.style-guides

Nate Wood, *North Dakota State University*

Vexation

Hate. I remember, as a child, being told never to use that word. I was only about 5 years old at the time and did not really grasp the logic underlying this admonition given me by some adult (my uncle, probably): it was something to do with the mere use of the word being equivalent to wishing for the damnation of the person to which it was directed. I still don't I get it. Even so, I've come to understand hatred to be a profoundly strong sentiment. So I use the term rarely. More to the point, I use it in my title advisedly. Though, to be fair, while I have developed a distain for those documents I see as being ironically[1] categorized as "style-guides," it is the Vogons who uncritically adopt their guidance as dogma that I really despise … No. In reality, I don't actually hate them either. But I have grown weary of protracted discussions about whether every document that finds its way into the hallowed halls of the academy should conform to APA guidelines, whether it is acceptable for a single sentence to comprise a paragraph, and the endless barrage of questions from students about the bounds for length, font-size, spacing, margins, etc. for written assignments. And it is the dogmatic adherence to so-called "style-guides" that I am convinced underlies these diversionary diatribes.

Soooooo….

At this point, an academic reader is likely to suggest that my title seems to do a poor job of describing the information contained in this proposal. I agree. But that criticism exemplifies a problematic metaphor by which we think language: words as containers for meaning. Seduced by this metaphor, we have a tendency to assume the key to clear communication is to assemble the right collection of words in the right way. And "style-guides" provide prescriptions for organizing those words in orders and amounts that, purportedly, most effectively (read: efficiently) transmit their meaning. They are about organizing the meaning containers. But the meanings of individual words are hardly unambiguous. As Gleick (2011) points out, for the definition of the word "make", the Oxford English Dictionary records 3 entries as a noun, 2 as verb, and 1 combination form – collectively representing well over 100 senses in which this single word has been used. The meaning of "make" is not *in* the word itself. Like most words, the meaning it effectively conjures depends complexly on its placement within the broader context of its use.

Here is the point I am trying to make: good academic writing absolutely requires meaning be clearly and precisely rendered. But there are no straightforward and reliable rules for doing that well – anymore than straightforward recipes exist for creating compelling music. While style-guides do provide some useful heuristics and conventions about organization, mechanics, voice, etc., they suck at helping individual writers find ways to render their meanings clear.

It is at this point in pitching this V&V I always get stuck. I have tried to articulate it on several occasions and one of the things that keeps stopping me completing it is, frankly, I am struggling to put my finger on what it is that is bothering me. Something vexes me about this. Has for years. I see it manifest in arguments over whether to use numerals or to spell-out single-digit numbers in ill-conceived policy documents. I see it manifest in a colleague's refusals to read (graduate) students' work if it contains sentences more than 12 words long. I see it manifest when (graduate) students offer me dictionary definitions in response to me tasking them with making sense of complex concepts. Certainly there are irritating aspects right on the surface of those examples, but I think my vexation is rooted in something underlying. These sorts of things have the feel of an evasion of responsibility to me. All of those examples seem, to me, like individuals abdicating responsibility for thinking.

[1] *An artist's style is birthed in innovation – in mindful deviations from convention.*

Nate Wood, *North Dakota State University*

As satisfying as I find it to critique the perverse pride academics take in wielding rules to obstruct meaningful discussion or disorient students, I think it may be more productive to focus my incubator session on mentoring graduate students to write meaningfully. I would argue that meaningful writing develops in two, sequential phases:

1) Writing to find out what I think
2) Writing to communicate what I think

But I struggle to explain that to graduate students – or help them figure out how to do it well.

Venture

I can offer an example that illustrates how I have worked toward better rendering meaning in my own writing. For decades, I have deliberately practiced writing like (read: imitating) authors whose work I enjoy reading. One of the first rules of grammar I remember learning was to never begin a sentence with "and" or "but" (the same rule applies to other conjunctions, but it is those two I remember being mentioned specifically by whichever teacher first indoctrinated me). So when I started reading Jerome Bruner's work, his use of conjunctions to begin sentences jumped out at me. I thought, if Bruner does it, why can't I? In essence, Bruner gave me permission to mindfully transgress what I thought to be a hard-and-fast rule for writing. And as I began to imitate this practice of beginning sentences with conjunctions, I found I liked the way it impacted the flow of the text. I wasn't really sure why, at first, but as I thought more about it I realized I had unknowingly begun to use this practice as a tactic to influence the cadence of my writing – and thereby emphasize particular ideas. I suspect it was my musical background that led me to work this way. Initially, I didn't do it intentionally. (I do now.) But as I have reflected on the development of my own writing style, I realize I use the beginning conjunction, along with other tactics, in an attempt to create rhythm, phrasing, and dynamics in my writing in order to underscore the meanings I hope to convey. I use long sentences to signal synthesis. Shorter ones to signal summation. Or emphasis. I over-used the beginning conjunction at first. Still do at times. And, in doing so, I find that, like adding seasonings when cooking food, the right amount makes a huge improvement - but too much quickly makes it unpalatable.

But I am not sure how to *teach* this. I have made fledgling attempts that amount essentially to suggesting students try some stuff that worked for me. I've tried telling students to identify authors whose writing they enjoy – and to reflect on what why they like it and how they can emulate it. But what I typically hear in response is 'I don't like so-and-so's writing because he uses a lot of big words and it's too hard to understand.' Or I hear 'I like what's-her-face's writing because it is easy to understand,' but they don't articulate what makes it easy to understand. Both of those responses become the beginnings of refusals to read challenging texts. I've also tried to explain that there are situations in which intentionally violating writing conventions can make one's writing more powerful. Few students are brave enough to try it when a grade is at stake for a written assignment. Others have missed the qualifier about making one's writing more powerful, and simply violate conventions for the sake of violating conventions. None of this accomplishes the goal of rendering meaning more clearly.

I suspect the problem is that I have been advising students to try things that worked for me when I should be helping them find tactics that will work for them. But I struggle to articulate what I am doing in terms of developing my own writing style is because I have engaged in this process of deliberate practice more-or-less intuitively. And I never actually met my most influential teachers in this process: bell hooks, Jerome Bruner, John Dewey, Douglass Adams, Eddie Van Halen… I made my path by walking. But how do I teach other people to do that – especially in the face of the seductive simplicity of those lists of formatting and organizational rules in those damned style-guides?

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