SCIENCE EDUCATION AT THE CROSSROADS

CLEVELAND, OH • OCTOBER 1 – 3, 2015

HYATT REGENCY AT THE ARCADE

Welcome!

Many presume that John and I are collaborators and co-researchers in all things. Some express the belief that he was my graduate advisor, or even currently *is* my graduate advisor as I'm launching into a new youthful career, him filling the role of the wizened professor. It's not true. We delve into different projects in disparate realms. While we enjoy sharing a table at the pub to talk about each other's projects, scholarly and otherwise, it's generally a conversation of contrasts, rather than of similarity.

And yet, recently we've woven with threads sourced from the same mill. Whether it's caused by our influences on one another or if it's happenstance, I'm not sure. John's research (which involves several of you coming to Cleveland) considers the infrastructures of schools and how those impact achievement gaps in student science outcomes. I've been poking around in a wide array of learning environments (including those familiar to some of you) to see what wisdom I could assemble from these. Although these are substantively different projects with entirely distinct methodologies and completely different impacts, we are able to talk about our work in terms of "space." Besides pubs, we're often contemplating while in the spaces of a vast desert expanse or the cramped quarters of a tent; in our work, we're each actively considering how learning is defined by walls or lack thereof, by an activities of personnel, or even by an established culture. All create the spaces we're interested in.

It should comes as no surprise that *Science Education at the Crossroads* is a source of fascination for us as academics. Crossroads is where our passions intersect in multiple forms. Whether gathered in Storrs or Alta or San Antonio or Cleveland, we've made use of particular spaces. From its inception, we've imagined Crossroads as a dinner party, complete with the polite dinner guests who are invited. As we've incorporated a culinary theme this year, that metaphor takes on deeper meanings. In my mind, it's become some odd mélange of a sophisticated reception with hors-d'oeuvres, a Friday evening celebration in the dorms, and a church potluck on a summer Sunday. A mix of people and plates and perspectives. John and I are the hosts – as much by default than by demand. We're donning aprons, scurrying about with final preparations. We debate whether to use the fancy taper candles and if we can get by with the stainless rather than the silver. John irons the linens while I'm puzzling over whether stemware goes to the right or left. Platters are dusted and set in place, and a seating arrangement – what follows in this program – is agonized over as we consider which sessions we will be missing while presenting our own Ventures and Vexations.

In a sense, the program on the next two pages and all the entrees you and your colleagues are venturing forth define the space. We've been lucky enough to curate and coordinate. In the pages that follow, you'll see how each piece fills the page and how you've paired with another presenter as well as matched to a Facilitator. As you turn the pages, you'll experience the array of diverse place settings occupied by colleagues – from teacher education programs, from science departments, from school classrooms, from museums, from research organizations. There are old friends, names you recognize, and ideas that are completely foreign. All begin to describe our architecture and ascribe the space we are about to occupy.

Then there's you. You fill the space even as your words and action help to construct it. The program shows when you are to take your appointed seat in a particular room and who the other presenter will be at the table. We've endeavored to preserve the tendency for Crossroads to transcend any individual and his or her situation. Instead, the essence arises from the activities and exchanges as ideas and individuals intersect with one another. What happens when Cheyenne and Rachel (or Savitha and Heather? or Asli and Lara? or …) are prompted to dish out their ideas to be chewed upon in the same 75-minute course by a self-selected yet attentive coterie of dinner guests? We don't know exactly and yet we are confident it will be generative.

Now, as we untie our aprons and finish an apéritif, we peak out the window to see who is arriving. As smart and sensitive as you are, you can't fully appreciate our genuine excitement and delight about what is about to transpire.

Adam Johnston & John Settlage
September 18, 2015

Program Schedule

Thursday, October 1st

noon – 7:00 pm	**Arrivals**	Hyatt Arcade, 420 Superior Avenue, Cleveland, Ohio
7:00 – 8:00 pm	**We Begin**	Reception, Welcome & Orientation John Settlage, Adam Johnston, Jenna Carslon and Kip Ault
8:00 – 9:00 pm	**Poetry**	My Favorite Poem Readings Assorted Volunteers
after hours	**Networking**	

Friday, October 2nd

9:00 – 9:15 am	**Welcome**	Re-Welcome & Fresh Introductions	
9:15 – 10:15 am	**Keynote**	There and Back Again: A Journey Through Learning Spaces Adam Johnston	
10:15 – 10:45 am	**Break**		
10:45 – noon	**Incubator A**	Medeith Kier & Noemi Waight (w/ Jenna)	**Smith**
		Beth Raynor & Scott McDonald (w/ Latanya)	**Eisenmann**
		Angela Johnson & Adam Johnston (w/ Kirby)	**Old Arcade**
noon – 1:29 pm	**Lunch**		
1:30 – 2:45 pm	**Incubator B**	Doug Larkin & Sarah Heredia (w/ Jenna)	**Eisenmann**
		Nate Wood & Bhaskar Upadhyay (w/ Latanya)	**Old Arcade**
		Rachel Wilson & Cheyenne Herland (w/ Shelby)	**Smith**
2:45 – 3:30 pm	**Break**		
3:30 – 4:45 pm	**Incubator C**	Jenny Igber & Brian Fortney (w/ Kirby)	**Eisenmann**
		Heather Mars & Savitha Moorthy (w/ Jenna)	**Smith**
		Carrie Allen & Rachael Gabriel (w/ Shelby)	**Old Arcade**

4:45 – 7:29 pm	**Free Choice**	Strolling, bowling, sight-seeing, noshing, beer sipping, dining, & talking …
7:30 – 8:00 pm	**Treats**	Dessert Reception
8:00 – 9:00 pm	**GUEST PRESENTER**	CHEF JONATHON SAWYER
after hours	**Chatting**	Keep the conversations going

Saturday, October 3rd

9:00 – 10:15 am	**Incubator D**	Kathryn Hayes & Karen Lionberge (w/ Jenna)	**Old Arcade**
		David Stroupe & Julie Brown (w/ Kirby)	**Eisenmann**
		Peggy McNeal & Brooke Whitworth (w/ Shelby)	**Smith**
10:15 – 10:45 am	**Break**		
10:45 – noon	**Incubator E**	Asli Sezen-Barrie & Lara Smetana (w/ Shelby)	**Eisenmann**
		Eugnia Johnson-Whitt & John Settlage (w/ Latanya)	**Old Arcade**
noon – 1:00 pm	**Lunch**		
2:00 – 3:00 pm	After Dinner Minutes	Final Considerations of All Things Cultural and Culinary and Crossroady	
3:30 – 11:30 pm	Museums!	Art, Culture, History, Food and Rock & Roll	

CHEF JONATHON SAWYER

2015 Science Education at the Crossroads Guest Speaker

Jonathon Sawyer is proudly from Cleveland Ohio, where he owns & operates

- his flagship restaurant The Greenhouse Tavern,
- Northern Italian restaurant Trentina,
- ramen mash up Noodlecat,
- and stadium spots Sawyer's Street Frites, Sausage & Peppers, & SeeSaw Pretzel Shoppe.

In 2010, he was honored as one of ***Food & Wine Magazine's*** Best New Chefs. Chef Sawyer has also made national television appearances including ***Iron Chef America***, ***Dinner Impossible***, ***Unique Eats***, and ***Best Thing I Ever Ate***. In 2015 Chef Jonathon Sawyer took home The James Beard Award for BEST CHEF: GREAT LAKES!!

When Jonathon is not in the kitchen he is surrounded by his family, his wife Amelia, son Catcher, daughter Louisiana, dogs Potato and Vito, and chickens Acorn, Bunny, Bear, & Squid. He can often be found in the cellar of his century home where he ferments beer & wine vinegars for the restaurants and for Tavern Vinegar Co. Jonathon is a tireless supporter of the green movement, local agriculture, and sustainable businesses both in Northeast Ohio and around the country.

www.noodlecat.com/#ramen www.restauranttrentina.com sawyersstreetfrites.com seesawpretzels.com

TEAM SAWYER is the restaurant group of
James Beard Award Winning Chef Jonathon Sawyer.

Mission:
To consistently deliver inspirational service to our friends by exceeding expectations of Team Sawyer's culinary essence and value.

Vision:
To compel the world to love and eat with us.

Beliefs:
1. We put our family first.
2. We encourage immediate, honest and respectful communication.
3. We are committed to giving.
4. We trust what we value, we value what we trust
5. Work should be fun!
6. Life responds to your attitude.
7. The whole is greater than the sum of its parts.
8. Positivity wins!!

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. The session lasts for a 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 certain structure to also provide people with freedom. 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 2015 Crossroads are volunteering their time to assist in this event and their efforts make all the difference. We grateful acknowledge their involvement and appreciate the consideration extended by their supervisors, partners, catsitters, etc. Each deserves admiration and accolades and refreshing beverages.

Jenna Carlson **Kirby Whittington** **Latanya Brandon** **Shelby Little**

Incubator Etiquette

1. We discourage moving between sessions with a timeslot. While such practices are common at other conferences, here it reduces trust-building and idea exchange.
2. We encourage a uniform distribution across sessions. If you notice a crowded or sparsely populated room, consider doing your part to balance the numbers by being generous with your presence.

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 would be as a paper presentation:

Your name. (2014). Title of your talk. Paper presented at the annual meeting of Science Education at the Crossroads, Cleveland, OH, Octboer 1-3 [Available online at www.sciedxroads.org/proceedings2015.html].

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

Your name. (2014). Title of your talk. In J. Settlage & A. Johnston (Eds.), Proceedings of the Science Education at the Crossroads Conference (pp. xx-xy). Cleveland, OH. [Available online at www.sciedxroads.org/proceedings2015.html].

Supporting Teachers in their Efforts to Enact Effective and Enduring Reform in Science Education

Carrie D. Allen, ***University of Colorado, Boulder***

Vexation: Organizational challenges to implementing reform

Recent reform efforts in science education, such as *The Framework for K-12 Science Education* (NRC, 2012) and the *Next Generation Science Standards* (NGSS Lead States, 2013), present a rich opportunity to revisit effective practices for and challenges to reform implementation. Like earlier generations of reform initiatives in science education, the *Framework* and *NGSS* present a vision that suggests significant changes for educators' instructional practices. The emphasis of engaging students in science practices as a means for developing understanding of disciplinary core ideas and crosscutting concepts diverges largely from instructional approaches most prevalent in science classrooms today, which tend to focus on the development of content knowledge alone. However, supporting teachers in making reform-aligned shifts in their instructional practice can be difficult, if not daunting.

Prior research on reform implementation points to professional development (Garet, Porter, Desimone, Birman, & Yoon, 2001; Penuel et al, 2007; Supovitz & Turner, 2000) and curricular materials (Brown, 2002; Davis & Krajcik, 2005; Remillard, 2000) as being necessary supports for teachers' integration of reform ideas and practices. However, even with support from professional development and curriculum materials, teachers are likely to struggle with enacting reform in their classrooms. This is, in part, due to systemic incoherence (Allen & Penuel, 2014).

Educational systems have multiple, interlocking components that are only partially coordinated (Lemke & Sabelli, 2008), and successful implementation of reform requires strong coherence among key elements of the education system. Dimensions of coherence include ***vertical coherence*** in which teachers and building leaders have a shared belief about the purpose or value of adopted reform; ***horizontal coherence*** between policy and curriculum used, teachers' instructional practices and professional development; and ***developmental coherence*** in which policy coheres with our current understandings of how children develop over time (National Research Council, 2006, 2012).

Further, systemic (in)coherence – and particularly teachers' ***perceptions*** of coherence – weigh heavily on teachers' decision-making regarding what aspects of reform to implement. For example, reform texts may lack coherence with other school or district curriculum materials, such as pacing guides or district-adopted texts (Allen & Penuel, 2014). Messages from PD may suggest ideas about teaching and learning that come into conflict with other standards and instructional expectations within teachers' schools. Even within the same district, schools can have such varied leadership and institutional demands (i.e., meeting NCLB accountability measures) that reform implementation can manifest in dramatically different ways across schools. Therefore, even when teachers are committed to the ideas in reform, their efforts may be stymied by existing organizational practices (Carlone, Haun-Frank, & Kimmel, 2010).

How then, do we support effective and enduring reform in science education? And, in particular, how do we ally with teachers in their efforts to make changes to their instruction that are beneficial for students but not yet adopted broadly or reflected through teachers' organizational practices? These questions are the heart of this proposal.

Venture: Design as opportunities for sensemaking toward systemic coherence

I have begun to take a deeper look at when and why reform efforts are stymied and when they take hold by utilizing a framework from organizational studies, called ***sensemaking*** (Weick, 1995). Sensemaking affords analytic leverage for understanding teachers' interpretations of reform, their patterns of implementation, and the ways these are shaped and sustained (or not) by organizational (school and district) practices. Through this framework, the introduction of new ideas in reform initiatives are experienced as "shocks" to those within the system (Weick, 1995); and, the processes educators undergo to reduce and diminish the kinds of ambiguity and uncertainty that emerge from those "shocks" are experienced as ***sensemaking***.

As teachers engage with the *Framework* and *NGSS*, they are likely to encounter ambiguity from conflicting goals for instruction, such as competing district initiatives; limited resources to support instruction that aligns with the standards (e.g. curriculum materials, time to plan new lessons/units); a lack of clarity with respect to roles and responsibilities with the new standards; and the absence of measures (e.g. assessments) for judging how successfully they have accomplished goals of reform (Weick, 1995). Additionally, teachers are likely to experience uncertainty around what reform means for how and in what ways the different aspects of the system are changing as a result of *NGSS* (Weick, 1995). In their sensemaking in response to these sources of ambiguity and uncertainty, teachers are likely to draw on their personal resources – such as their histories teaching, their prior experiences with reform in education, and their beliefs about teaching and learning – and their social resources – such as professional learning communities (Weick, 1995; see also Coburn, 2004).

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By documenting teachers' expressed concerns and questions within professional development workshops that introduce the *Framework* and *NGSS* and through teacher interviews after professional development and during classroom implementation, I have tried to identify and categorize the sources of uncertainty and ambiguity likely to emerge for teachers when engaging with and trying to implement these ideas. Prior research suggests that when teachers have sustained engagement with conflicting ideas with the explicit goal of making sense of them and reconsidering what is "already known" (Smith, Snir, & Grosslight; Strike & Posner, 1985, 1992) these activities can support teachers' emerging ideas of reform. Activities such as these are *sensegiving* (Gioia & Chittipeddi, 1991) in that they can productively shape teachers' ideas of reform. In identifying these sources of ambiguity and uncertainty, my aim is to design future professional development that organizes activities around these sources in ways that are productive for teachers in terms of their development of a robust understanding of reform and systemically-coherent materials for supporting their implementation.

To guide the design of activities that are sensegiving for teachers, I have drafted a conceptual model of teachers' sensemaking of reform (Figure 1). This model draws on what we know from organizational theories regarding sensemaking, and on empirical evidence of effective professional development and the role of school and district practices in organizing teachers' instruction. I argue that to productively support teachers' implementation of reform, we, as teacher educators and researchers, need to consider all aspects included in the conceptual model: (1) ***professional development*** (PD) activities that embody the vision of the reform and that provide teachers with opportunities to align their current instructional resources with these ideas; (2) ***instructional guidance infrastructures*** (IGI; Hopkins & Spillane, in press), such as pacing guides and existing standards; (3) ***teachers' personal and social resources*** (P+SR); and (4) their implementation of reform-espoused instructional practices as an iterative outcome of sensemaking.

Conceptual Model of Teachers' Sensemaking of Reform in Education

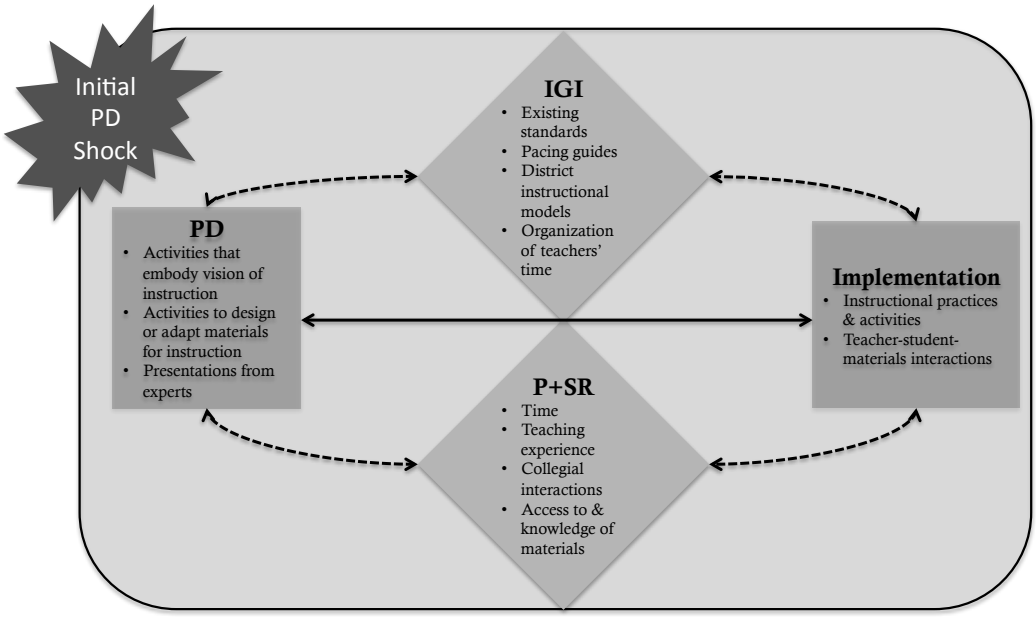

Figure 1. Conceptual model of teachers' sensemaking of reform in education

For example, if we apply this model to the experience of Abby, a sixth grade middle school science teacher who surfaced conflicting goals that emerged between her district's pacing guide (IGI) and curricular materials meant to support her implementation of the goals of NGSS (P+SR), then we would consider how to design PD activities that would support Abby's sensemaking so that she was able to adapt the curricular resources in ways that better cohere with the IGI of her system. For our discussion, I would like to us to deliberate about this model: What do you see as the productive lever points in this model? Are their aspects of reform implementation overlooked, not considered? Lastly, I'm concerned that a model like this is may cast implementation as a definitive end goal rather than an iterative process that involves teacher choice and expertise. How might we account for teacher agency within this model of sensemaking?

The Incredible Flatness of 3D Learning

Charles "Kip" Ault, ***Lewis & Clark College (emeritus)***

My cradle to grave vexation

MY VEXATION HAS DOGGED ME MY ENTIRE CAREER. It started as I came to regret asking students to mark observations with an "O" and inferences with an "I" on a midterm for a course on science process skills. They were statements about a pencil and I cannot erase their inanity from my mind. I've felt the need to do repentance ever since.

Recently, a friend lamented in an email to me that "As an active teacher in a public school there is a feeling that if you are not on the NGSS [Next Generation Science Standards] bandwagon you are marginalized." A fellow dissenter. As someone who never boarded the bandwagon, I am vexed by the lack of dissent among science educators to the NGSS and their precursor, the NSES (National Science Education Standards).

Not curmudgeonly dissent ("we tried that and it didn't work") or alignment fatigue, but strongly argued dissent questioning fundamental premises of the NGSS and their precursors going back to teaching "the" scientific method in four, five, six, seven, or even eight steps. There is political opposition to a few particular claims in the NGSS about climate change (and perennial challenges to evolution) coupled to the growing resistance to testing. Most states have hitched adoption of the NGSS to the Common Core and advocates of local control often object to both with one convoluted argument or another.

But I'm talking about features that the NGSS boosters and their Achieve partners truly believe in. I'm vexed by the notion that two unifying dimensions focused on a disciplinary core idea will generate performance expectations. The NGSS bandwagon stresses this expectation as "3D learning." However, the first dimension, "scientific practices," mostly recycles the rhetoric of teaching science as process. The third dimension, "crosscutting concepts," mostly repeats the earlier common themes of Science for All Americans. The two dimensions that sandwich core ideas premise an underlying unity among the sciences that falls quiet flat. Their application suggests that disciplinary ideas lack vitality and dynamism–that they are relatively inert propositions incapable of generating performance expectations.

I worry that very few acknowledge the existence of such an issue. Hence, the feeling of marginalization.

I speak the language of anti-3Dism with a voice anchored to respect for the diversity of scientific enterprises. Rather than seek universals of practice or habits of mind common to all the sciences, I place value in the plurality of expertise across disciplines. Instead of splitting "content" from "process," I view concepts as tools of *inquiry* put into action to solve problems. Context is crucial; concepts, while differing in degree of abstraction, serve specific purposes. "Homology," for example, guides both the thinking and doing of puzzling out evolutionary ancestry. "Frame of reference" spans kindergarten learning to recognize left and right from someone else's perspective to solving problems of cosmic motion. "Modern analogues" provide purchase for reasoning about complex landscapes on multiple scales. Such concepts have the oomph to generate performance expectations. 3D alignment obscures how the core ideas might auto-scaffold when primed by such thinking.

No one really lost this debate because the debate never happened (perhaps with the exception of in my head). Reform keeps rebottling the old wine. Part of the trouble stems from standards not being curriculum. Finding concepts problem by problem that function as tools of inquiry means building a curriculum, one that need not bend to the arc of universal science.

Making waves in a fourth-grade venture

So, I'm vexed. Now retired, I feel out to pasture yet still kicking. Is anyone listening? Has anyone paid attention to a career's worth of argument? This December I will be a scientist-in-residence for a month at an elementary school. I have joined the fourth-grade team to plan a unit on Physical Science Core Idea 4-4: Waves and Their Applications in Technologies for Information Transfer. The NGSS performance expectation at first glance feels appropriate: "design and build a device that uses sound or light to communicate over a distance." The guiding practice is to design a device to solve a problem and the crosscutting concept is that people depend upon various technologies.

Upon more in depth inspection, the NGSS 3D approach neither helps the teacher know what to do or what students ought to understand–about waves or information transfer. Planning begins within a vacuum. The district has no curriculum for teaching about waves and information transfer. Relevant teacher background knowledge is sparse and the topic almost mystifying. It's

Charles "Kip" Ault, ***Lewis & Clark College (emeritus)***

been added to the core ideas and was not part of the original standards. Where to begin? With ideas about waves and wave patterns, perhaps (think Slinky), and an emphasis on sound as vibration patterns. Maybe the 1960s *ESS Musical Instrument Recipe Book* can spark ideas. Hmmm . . . talking drums (messages built upon tonal languages of Africa)? Devices that signal using Morse code? Dropping stones in pans of water?

Engaging activities are essential, but there needs to be a small population of concepts about waveforms and information transfer. What are they? Where are they to be found? If 3Dism falls short (yes, there are a few content paragraphs to read that recount basic ideas), then where to turn for conceptual guidance in developing lessons? These questions call for curriculum where none exists. Pitch, loudness, harmony, reverberation–qualities of sound–need to be linked to abstract ideas such as frequency, amplitude, resonance, reflection, and interference. Circumstances no doubt call for the reinvention of the wheel–a wheel that makes many sounds; a very squeaky wheel.

The concept of "vibrations," serving as a *tool of inquiry*, generates expectations. Thoughts of "vibration" must echo in the children's minds. Imagine a starting point: a forearm waving from the elbow–a human metronome and inverted pendulum. The waving hand's position is graphable with respect to time: to the left, then back to the right. Wave faster; check the graph. Wave farther left and right; check the graph again. The graph records the pattern of motion in waveform. Such waveforms may represent sound on a graph that graphs vibrations. When information is being transferred, the question becomes, "What's waving?"

Back to demonstrating understanding by designing and building an information transfer device. We have three lessons a week for three weeks to achieve the intended outcome. Looks like it will be a whistle, drum, flute, horn, string, or reed instrument of some sort. The trick will be to map information onto the qualities and property of the sounds the instruments make.

Initially, the engineering component flummoxed the group–but ultimately it energized them as they began to imagine things to do with tubes and funnels, straws and sticks, boxes and strings. The trick is to keep attention on the phenomenon of interest–vibrations–and their representations in wave form. That's my venture.

I maintain that the proper starting point is to consider the challenge: the challenge of adapting thinking and doing to the problem at hand, not to alignment with generic NGSS descriptors. We invent and engineer concepts, test their worth through inquiry, and match methods to their meanings:

> **A fresh line of scientific research has its origin not in objective facts alone but in a conception, a deliberate construction of the mind. On this conception, all else depends. It tells us what facts to look for in research. It tells us what meaning to assign to these facts.**
>
> **--Joseph J. Schwab, The Conception of the Structure of a Discipline,** ***The Educational Record, 43*** **(1962): 197-205.**

To these fourth-grade teachers my flatness criticisms of 3D learning matter very little. The standards pick the target; the district mandates that they aim for it. Imagining good ways to interact with the children dominates planning. The NGSS roll out proceeds unabated, the few dissenters at the margins. So I ask, am I just a voice shouting in the wilderness?

Physical Sciences: Connections within and between Communities

Brian Scott Fortney, ***The University of Texas at San Antonio***

Vexation

I am thankful for the support of the *Crossroads* community. Recently, I have moved to a new university, and am teaching Physical Science as an Assistant Professor in the College of Education and Human Development. This is a change from my past experiences as an Assistant Professor teaching science methods courses at the elementary, middle, and secondary levels. In the past two years I was the only science educator in the Department of Teacher Education. Therefore I was expected to pick up the research and duties of several colleagues who had recently left the Department. My identity as a science educator, and my research agenda were severely impacted. My *Crossroads* community helped provide perspective in the disturbing landscape. For this, I am truly thankful. My new venture at the University of Texas at San Antonio returns me to my interest in creating opportunities for preservice teachers to experience teaching science–possibly different from their prior experiences. These past two years, I have utilized the concept of Lifeworlds by Lim and Calabrese Barton (2006) to underpin my science methods instruction, since a lifeworld "represents the ideal that a set of lived experiences is the core of each being" (Lim & Calabrese Barton, 2006, p. 111). Through immersion in courses with cohorts of preservice teachers and involvement in outside activities, individual student backgrounds and experiences became visible, as well as their stories and perspectives on teaching science, and student learning in science. Thus, I was able to seek understanding of individual preservice teacher beliefs and experiences in various domains of science and science classrooms, then challenge each individual to reflect on memories and feelings about past experiences in learning science through a set of strategically designed inquiry lessons. Even though this next year I will not be teaching science methods, I will continue to challenge undergraduate preservice teachers to think and interact with scientific content differently than they may have in the past. I wish to ask for advice from the Crossroads community regarding connections and opportunities, "positives", and pitfalls/unintended signals of my new venture.

Background

My research seeks to understand and articulate dynamic connections between an individual's beliefs about the sciences (and teaching science), and their practice in the classroom. This complex link appears dynamic and flexible, with "weightings" of beliefs changing as rapidly as changes in context. Thus, preservice teacher practice may change as quickly as context. Why does this happen? In some perspectives, it may be indicative of deeply held beliefs that are not in line with practice, while to me it is a complex and dynamic combination of personal epistemology, beliefs about teaching and student learning, depth of content knowledge of the topic, and ontological beliefs about teaching and student learning–all vying for context-dependent influence.

Example

As a beginning teacher of chemistry and physics at the secondary level, I highly favored hands-on activities and development of fundamental concepts across topics and domains. I defined *learning* as individual students actively seeking to understand new information in light of prior experiences and knowledge, either through working in groups, questioning, or inquiry, for example. On the other hand, *understanding*, or the development/construction of understanding is defined as deepening knowledge and connections between domains, or within the same domain, through connections between topics. Personally, a noisy classroom required attention to student conversations, and quality of reasoning. My department chair, however, did not share the same framework. He described learning as only occurring when students are quiet. No learning is occurring if the classroom is noisy. His evaluations reflected this perspective.

Fundamentally, I understood that I was required to have highly positive observations and reviews. As a beginning teacher in Chicago, Illinois, it was common to receive a pink-slip/"RIF", or Reduction in Force at the end of your first year, thus requiring a second probationary year. Therefore, having one "less-than-favorable" teaching evaluation highly weighted the impact of "keeping my job" on my teaching behaviors. I was told to have a "canned" lab or activity that I might use during the day of my teaching evaluation observation, and I could pick up the pieces the following day. Walk-through/informal observations were even more un-nerving. The end result of a formal observation or informal observation was a quick-shift from my normal teaching behaviors to a lecture-based or

question-answer based format. I changed my teaching behaviors to be consistent with beliefs about teaching and student learning that I did not hold.

While this shift may have been extreme, it is but one example of how classroom teaching behaviors might shift with change in context and perception. Indeed, as I challenge preservice teachers to make sense of-and try-new teaching pedagogies and perspectives, I ask them to evaluate the result of their efforts and behaviors. Whether good/bad, positive/negative, I seek to understand the ontological images and definitions that students use as a comparison, as well as their personal epistemologies regarding teaching and knowledge of content. Each aspect dynamically impacts their teaching behaviors.

Venture

As I shift institutions, I have two requests, but I am clear that my past situation was both extreme and dis-empowering. Moving on from these experiences, I am acutely aware of, and sensitive to political winds, agendas, and methods of de-humanization and disempowerment. First, the past two years have required me to separate/isolate (repress?) my frustrations about not being allowed to pursue my own research agenda. As a consequence, I feel as if I have lost my identity as a science educator. Currently, I am floored at how my senses of wonder and creativity have flooded back, with change in context and university. My first request: As I work to nurture the sense of fascination and wonder in my work on the development of teacher identity in STEM preservice teachers, I worry that I will commit to duties which require significant time on another's research and/or, for example, community involvement or service. I ask for *Crossroads* colleagues' personal experiences and vignettes/experiences of others that tap into the rich experiences of community involvement, with an eye toward tempering time commitments. For example, I just learned that our college is losing one experienced science educator, and someone needs to take over some of the duties. While I am a team player and a strong supporter of my colleagues and students, I need to ensure that I do not over commit my time. How might I remain immersed in context with preservice teachers such that I might continue my work, but avoid the perception that I am unwilling to help? Full disclosure: I have a department chair who is genuinely interested in protecting new faculty, and has initiated monthly mentoring meetings with all new faculty. This includes holding the power to remove particular service to the department, college, or university as warranted. This, I sincerely respect. I am, however, unsure if this applies to university-community service.

Second, my identity as a teacher educator was severely challenged over the past two years. As I return to my research agenda I am concerned about expanding my research from beliefs about teaching science and student learning in science to include an individual's beliefs about content knowledge, and quality of content knowledge. (I am not concerned about my knowledge of content in chemistry and physics.) I seek advice and words of experience designed to help me avoid sending unintended signals resulting in commitments that impact my identity and research. Too, there is a large emphasis on connections with the community utilizing a social justice framework, which is also a personal area of deep interest.

From the Interdisciplinary Learning and Teaching Department [ILT] in the College of Education and Human Development at the University of Texas at San Antonio course catalog (ILT, 2015) "The mission of the Department of Interdisciplinary Learning and Teaching is to:

- Advance the intellectual and professional development of students and faculty through research, critical reflection and dialogue, social responsibility, and transformative leadership;
- Promote equality and social justice by advocating for educational change and reform; and
- Nurture the personal and professional integrity of all learners. "

Interrogating the Complementarity of Culturally Responsive and Reform-Based Science Education in K-12 Classrooms

Julie C. Brown, ***University of Minnesota***

Vexation

Science as it is taught in K-12 classrooms in the United States exalts Western Modern Science (WMS) above other cultural forms of knowing and practice (Nadeau & Desautels, 1984), though it is not often treated as a cultural phenomenon (Bryan & Atwater, 2002). Thus, scholars argue that bridging students' backgrounds with WMS content and practices is necessary for the academic success of students of color by reducing incongruences between home and school norms (Aikenhead & Jegede, 1999) and increasing the authenticity of science learning (Buxton, 2006). One approach to equitable science is through culturally responsive science teaching, which "teaches to and through [students'] personal and cultural strengths, their intellectual capabilities, and their prior accomplishments" (Gay, 2010, p. 26). In theory, culturally responsive science teaching seems an ideal tactic for mitigating chronic gaps in science achievement between students of color and their White and Asian counterparts (Abrams et al., 2014). In reality, classroom occurrences are disappointingly rare.

Science teachers are often underprepared to educate culturally and linguistically diverse students (Song, 2006) and struggle with teaching in ways that are culturally responsive (Patchen & Cox-Petersen, 2008). In my work developing culturally responsive, reform-based (i.e., engaging students in the science and engineering practices espoused in the National Research Council's (NRC) (2012) *Framework for K-12 Science Education*) secondary science teachers from 2012-2014, I found that even when teachers embrace culturally responsive science teaching they are often left "all dressed up with nowhere to go." In other words - once equipped with an understanding of central tenets of both general and discipline-specific culturally responsive pedagogy, students' backgrounds and experiences, and critical perspectives on education - science teachers demonstrated narrow implementations of cultural responsiveness in their classrooms beyond fostering caring, respectful relationships and redistributing authority. Over the years, the teachers with whom I have worked infrequently integrated students' culturally-based knowledge and Indigenous Knowledge and Wisdom (IKW) with core science content, resulting in limited enactments of discipline-specific cultural responsiveness.

Science teachers and their students operate within an educational system driven by high-stakes standardized testing and standards-based curricula (Au, 2007). In schools were responsiveness is most needed, there is a documented political backlash associated with culturally responsive teaching, leaving schools with underachieving students more often pressured to conform to standardization rather than responsiveness (Sleeter, 2012). Commonly, reform-based science instruction (as a proxy for WMS) is treated as a way to achieve "Science for all." Yet, "inquiry-based instruction without culturally responsive pedagogy...may not be sufficient to support non-mainstream students in science learning and may even serve to challenge students' cultural ways of knowing" (Meyer & Crawford, 2011, p. 525). Though scholars have suggested a complementarity between reform-based and culturally responsive science instruction (Brown, 2014; Johnson, 2011), there exists limited evidence attesting to this (Tan, 2011). Still others have argued that tenets of reform-based science instruction may both collide and overlap with culturally responsive practices (e.g., Lee, 2004). Personally, I believe that harmony does and *must exist* between the two in order to advance "Science for All" at the classroom and political levels. Explicating the complementarity of innovative pedagogies – such as culturally responsive instruction – with reform-based science increases the potential for their widespread advancement (Sadler et al., 2006). Thus, there is merit in examining their intersection and is where my agenda is firmly rooted. By interrogating and reporting upon the intersection of reform-based and culturally responsive science education, the implications are both scholarly and practical: findings provide direction for possible future research and allow for new conversations to be had, hopefully in policy and research forums. Practically speaking, I envision results being applied to an empirically grounded framework for preparing culturally responsive science teachers.

Venture

Currently, a graduate research assistant and I are conducting a qualitative metasynthesis to explicate patterns associated with the intersection of culturally responsive/relevant practices and reform-based science instruction in the current empirical literature. Qualitative metasynthesis is an accepted approach for rigorous inductive analyses of existing studies (Thorne et al., 2004) and has been defined by Au (2007) as, "synthesizing the results of qualitative studies to gain a better understanding of the general nature of a given phenomenon" (p. 259). A primary goal of metasynthesis is "enlarging the interpretive possibilities of findings and constructing larger

Julie C. Brown, ***University of Minnesota***

narratives" of generalizability (Sandelowski et al., 1997, p. 369). Through the metasynthesis, the research assistant and I seek to identify and describe attributes and tensions of this intersection. In our process of integrating findings from qualitative research, we aim to build an abstract model of culturally responsive, reform-based science through these studies. Though we are still analyzing data, I will share our data collection and analysis procedures to this point.

Studies were selected if (i) culturally relevant/responsive science education was a "central feature" of the article, (ii) they occurred in or pertained to K-12 science education across formal and informal learning environments, and (iii) were published between 1994 (when the term *culturally relevant teaching* was first introduced by Ladson-Billings) and present. We made the determination of "central feature" on the grounds that (a) culturally relevant/responsive pedagogy was the guiding theoretical framework, (b) the research question(s) specifically examined culturally relevant/responsive pedagogy, and/or (c) findings reported extensively on cultural relevance/responsiveness in K-12 science education. We engaged in two rounds of study selection. In the first round we searched academic databases (*Academic Search Premier, ERIC, Education Full Text*) with keywords such as "culturally relevant", "culturally responsive" and "science education." Similar to Brotman and Moore (2008), for our second round we used the same keywords and searched nine premier science education journals, some including: *Journal of Research in Science Teaching, Science Education, Cultural Studies in Science Education,* and *International Journal of Science Education*. This process yielded 54 possible studies, which were further filtered to ensure they met inclusion criteria. We excluded work that did not allow for coding instances of either culturally responsive pedagogy (CRP) or reform-based science practices, such as position papers and empirical studies reporting survey results, teachers' perceptions, and program evaluation. The final sample totaled 24 studies.

Consistent with the metasynthesis approach, data were first deductively coded according to a priori codes assigned as indicators of culturally relevant pedagogy and reform-based science education (Thorne et al., 2004). To represent culturally relevant/responsive instruction, we used the *Culturally Responsive Instruction Observation Protocol* (CRIOP) (Powell et al., 2012), which operationalizes 25 CRP facets, and Ladson Billings' (1994; 1995) three CRP goals of academic success, cultural competence, critical consciousness. The eight NRC (2012) practices represented reform-based science instruction. We coded instances of actual classroom practice identifying both culturally responsive and reform-based science practices. Based on preliminary analysis, we separated the NRC practice *developing and using models* into those that used WMS and those eliciting Indigenous Knowledge and Wisdom. We isolated and quantified coded examples with the results representing instances of complementarity between CRP and reform-based science instruction. Specific themes were identified and expounded using evidence passages across the data. We hope to discuss these with the Crossroads community at the meeting.

Although the preliminary findings excite me greatly, I am still struggling with elements of the project and turn to my Crossroads colleagues for clarity and compassionate critique on the following:

- Implicit assimilationist and subtractive undertones associated with examining this intersectionality, which is certainly not what we endeavor. I am being reflexive throughout, but am seeking suggestions for certain paths to avoid and affirmation that certain elements are valuable and warranted. For example, what, if any, concerns/opposition might exist? What are likely ways to rebut these concerns? What, if anything, are we not attending to that we should be?
- Visually representing our preliminary findings, which currently vacillates between a 2-dimensional column chart and a 3-D version similar to the approach used by Gresalfi (2009). As we informally discuss preliminary trends we also at times end up with a Venn much like the third space diagram constructed by Glasson et al. (2010), with one sphere representing reform-based science (i.e., NRC, 2012), another representing CRP (i.e., CRIOP and Ladson-Billings, 1994; 1995), and their intersection as culturally responsive science. However, considering there are eight NRC (2012) practices, 25 CRP indicators in the CRIOP, and three goals identified by Ladson-Billings, this is a bit cumbersome.
- Lost perspectives due to strict adherence to our inclusion criteria. In our search we encountered many rich empirical studies that do pertain to culturally relevant topics (e.g., studies utilizing *funds of knowledge* and *third space* frameworks) but do not meet our criteria; we draw from a small sample of empirical articles (n=24). Thus, I worry if we provide a comprehensive depiction of complementarity.

Wanted: Theories of Teacher Development for Investigating Teacher Preparation, Development and Evaluation Policies

Rachael Gabriel, ***University of Connecticut***

Vexation

Over the last few months I've come to view my question about the potential of teacher evaluation to influence or sustain teacher professional development as an octopus playing twister by himself. When I try to untangle the legs and pin them to dots that make sense, I get re-tangled. I want to be able to study the effect of different rubrics and routines for observation and feedback in order to demonstrate whether and how teacher evaluation can support teacher development. I have done some analyses of the differences across various rubrics used for high-stakes teacher evaluation within and across states and found what I think are substantive differences in focus, content, format and possible applications. These differences would theoretically have a large impact on the potential of various tools and routines to support teachers, teaching and opportunities for learning. However, without a theory of how observation-feedback cycles might support teacher development, I am having trouble designing a study (or set of studies) that compares the fruitfulness of varied tools and routines for observation and feedback.

This is a problem because new generation, high-stakes teacher evaluation systems are not only sweeping the country (46 states have changed their policies in the last five years), they will also likely influence, eclipse or supplant funding and systems for professional development. In order to receive federal funds and/or NCLB waivers, states have had to agree to tie professional development to teacher evaluation systems. Though this seems like a good idea on the surface, it depends on teacher evaluation systems to be able to accurately and ***fruitfully*** identify and support (or connect to) professional development efforts. Though a connection to professional development is a good idea, there is no evidence that evaluation activities themselves support teacher learning, or accurately identify areas for other systems to support learning.

If teacher development is limited to changes in observable practices, or changes in student test scores, this would be easy to conceptualize and study. But I think we need a higher bar for quality than effect on scores or a set of specific behaviors. So far, I have not been able to identify a theory of teacher development that would frame a study of the effects of engagement with the tools and routines of teacher evaluation. Though no one can explicitly define teacher effectiveness across grades, subjects and contexts, everyone from teacher preparation programs to teacher evaluation policies claims to be able to develop it.

There are mini theories about the importance of things like teacher knowledge, employer feedback, professional networks, and teacher beliefs. And, there are major theories about adults as learners, expert and expertise development, and situated learning (and many more). But, I know of no unifying theory of teacher development that cuts across all the mini-theories used to guide efforts in teacher preparation, support and evaluation that aim to support or measure development. This makes it difficult to generate theory-rich answers to key questions about teacher preparation, support, evaluation and development like:

1. How prepared is ***prepared enough for teaching*** and how do we know?
2. (How) Is a teacher ***getting better*** at their teaching?
3. How ***effective*** are professional development efforts (especially those aimed at "capacity building" or teacher development rather than instrumental compliance or fidelity)?
4. What is the ***impact*** of evaluation processes and routines ***on a teacher's development?***

This question has larger implications, but I am specifically interested in generating empirical evidence to support my intuitive sense that different rubrics for observation have different consequences for the kinds of teaching that are supported and developed. For example, in states like New York, 10 or more rubrics are officially approved by the state for use in high-stakes teacher evaluation. They do not measure the same things in the same way, they cannot be equally effective at supporting development, but there is not yet evidence of their differential impact. I want to make some.

Venture

I'd like to be able to design a study that compares various rubrics and routines for observation and feedback, but I'm stuck with practitioner perception (do they like these tools) or with be to measures of student achievement. In other words, I can ask practitioners which rubrics and routines for reflection, debriefing and feedback they like the best. And/or I can look across settings where different

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tools and routines are in use to track changes in student achievement over time, but both of these avenues are unsatisfactory for different reasons.

In the first case, positive views of evaluation tools may not indicate fruitfulness. In the second case, it would be nearly impossible to isolate the effects of evaluation tools used across settings. In addition, changes to measured student achievement wouldn't be the most interesting or important indications that teachers are developing as a result of evaluation routines. It just means one set of kids got higher scores on some test one time.

I'd like to propose that the goal of feedback from evaluation observations is not that teachers necessarily change behavior or increase test scores, or even get higher evaluation ratings (they may already be high). I think the goal of feedback should be that teachers learn something more about why they do what they do (or don't do). So much of the literature on teacher qualifications is about what teachers "know and can do" (e.g. NBPTS standards). So much of the professional development literature is about changes in observable practices - essentially, teacher behaviors - rather than something internal or intrinsic to the teacher that might apply across practices. It can't just be that teachers do something different or know something different after feedback, but that teachers know more about what they do whether it's different or not. This would avoid the trend towards professional development focusing on development (additive changes) instead of teacher learning (Webster-Wright, 2009).

If I propose that the goal of feedback is teacher learning, and that learning is only important if it lies at the intersection of knowing and doing (e.g. knowing why you do what you do), I'm not sure how I would measure it. I could have teachers think aloud about what they see and what they were thinking while watching videos of themselves before and after engaging with feedback from evaluation. It could even be videos of lessons that were observed and rated in order to generate the feedback. Then, I could analyze the videos for changes in behavior that relate to areas in which they did and did not receive feedback.

I see two immediate problems with this. First, I don't know that a change in their narratives is evidence of learning, or what else would be. Second, I'm not sure how to isolate the effect of observation feedback. What if teachers learn on their own, or attend some sort of outside learning experience in the interim? I could address some of this by only leaving a short time between observations, but that may not be enough time for teachers to change and/or learn as a result of feedback.

Alternatively, I could interview teachers and administrators about what they learned from the observation/debrief conversation. After all, teachers are not the only ones who are meant to learn from the process of teacher evaluation - administrators are supposed to accumulate knowledge about teaching and coaching by engaging in these processes. I'm not convinced that self-report

Another idea is to focus on a very specific practice that requires a known knowledge base. If I was focused on a single practice that has a somewhat closed or otherwise well-identified set of associated knowledge, I could measure the effect of feedback directly because I would know what to look for. This idea would let me see if feedback generated by various tools is more likely to lead to changes in behavior than knowledge, or superficial vs. substantive changes, etc. If this makes sense, how would I choose the practice to focus on? It would have to be something observable so that I could identify its presence/absence/levels of use in observation. It would also be something that relies on an established set of underlying knowledge that I could probe for. Finally, it would have to be common enough that I would be able to find teachers who would be likely to receive feedback about this practice in settings that use varied tools for observation (this varies by district in some states, though many districts choose a single state system by default).

Maybe one of these three possibilities, or a third I have not thought of, could be revised to measure changes at the intersection of knowing and doing. This would leave room for teachers to learn even when they do not get feedback that they should change. For example, if someone gets positive feedback about something they are doing and should keep doing, that confirmation can still be fruitful for teacher development. A fruitful bit of feedback doesn't necessarily have to lead to a change in behavior or a higher score the next time around. Figuring out how to measure effects of feedback would clarify the mechanisms by which teacher evaluation impacts teachers and teaching, and create a framework within which varied tools for evaluation could be compared.

Communicating Across Assumptions for the Purpose of Practical, Research Based Teaching Reform

Kathryn Hayes, ***California State University – East Bay***

Vexation

In the last six months, I have attended many days of NGSS Professional Development (PD) as a researcher and as a participant, and witnessed an incredible range of approaches. My colleagues at the Science Partnership took social-constructivist approaches to heart, and built in long term collaboration, inquiry, and teacher leadership opportunities. Their summer institute was characterized by teachers engaging in science content with faculty and coaches that they had known for four years; those relationships contributed to adaptive approaches to solving NGSS implementation issues at their urban districts. That same group (Science Partnership), constrained by the dictates of a state grant, created a different summer institute with over 100 teachers, very little relationship building, and an inflexible approach (all teachers had to do the same thing with no differentiation based on prior experience and district context). I witnessed district based NGSS PD that consisted of reviewing the NGSS standards line by line, and scholar led PD that was over 50% lecture. I believe that with NGSS we have a real opportunity to shift science teaching and learning toward engaging all students in critical analysis of scientific phenomena–but without excellent PD (which only sometimes deserves the moniker "Professional Learning"), these hopes will not be realized.

Part of the problem (and my vexation) is the extreme variation in assumptions underlying policies, roll out procedures, and the research that supports them. For example, one set of PD approaches rests on assumptions that equitable and excellent teaching and learning relies on teacher ownership and internalization, which in turn requires a long-term investment in a teaching force that is committed, prepared, and continuously learning (Hargreaves & Fullan, 2012) (a foodie approach, if you will). This is contrasted by approaches that implicitly assume that teachers simply need to be told what to do and given the proper external incentives, such as holding them accountable for student achievement--a business model or "teacher proof curriculum" (Darling-Hammond, 2004) (a hamburger helper approach). Scholars have examined the outcomes of both foodie and hamburger helper approaches. However, they rarely discuss the assumptions that underlie their research, setting the stage for blending blunders (hamburger helper with grass-fed beef?) and major miscommunications regarding PD practice. Compounding this issue is a lack of open communication channels between researchers, policy makers, and PD providers. This practice allows policy makers and PD providers to draw on the research that supports the decisions they deem most politically expedient or cost effective. If educational researchers were in greater habit of communicating across assumptions amongst themselves and with others, politicians and providers would have more tools at hand to make decisions (or perhaps would know to be ashamed by the 1-day read-the-standards PD).

It is critical that researchers communicate across assumptions in both literature reviews and dissemination. That is, there is a need to pull together and disseminate research in such a way as to acknowledge the underlying assumptions and how they guide both research design and examined outcomes. This is, of course, very difficult to do–which is why it has not been done very often, and remains a vexation.

Venture

With a robust body of research on excellent science teaching and learning practices, and with NGSS policies and assessments looming on the horizon, many science educators and researchers have grappled with the fundamental guiding questions, ***what is the relationship between PD and teacher shifts in instructional practice***? What is the role of district or school context in mediating this relationship? These questions are both practical and theoretical. Practically, how does a district, county office, NGO, or other organization interested in educational reform know how to proceed? What is going to help teachers shift their practice in any given context? Theoretically, there is a need for pulling together evidence from disparate studies that can range from establishing the significant role of content focus in teacher instructional shifts (Garet, et al., 2001), to qualitatively determining that teacher agency (voluntariness) is essential to reform implementation (Coburn, 2004).

Communicating Across Assumptions for the Purpose of Practical, Research Based Teaching Reform

Kathryn Hayes, ***California State University – East Bay***

Because policy makers, grant-making organizations (like NSF), PD providers, and NGSS roll out teams often take up research that resonates with their personal or institutional proclivities, my hope–the first part of my venture–is to provide a literature review to answer the above questions that draws together scholarship from across methodological and theoretical silos.

Recipe

I propose to approach this first part of the venture through adapting a particular recipe – a theory-building systematic literature review processes called a "realist synthesis" (Pawson, et al., 2004; Wong, et al., 2013). The process arose out of similar calls for "evidence based policy" in health-care systems, where, as in education, a causal focus on "what works" masks what works for whom, under what conditions, and most importantly, why. A realist synthesis aims to contribute to theory regarding the mechanisms which mediate how policies shift context, giving rise to particular outcomes. In brief, a realist synthesis consists of the following steps: After a systematic literature search, the researchers analyze the literature for patterns of outcomes (e.g., shifts in instructional practice), then document the mechanisms and contexts associated with those outcomes (Wong, et al., 2013). For example, teacher internalization of voluntary reforms may be associated, across multiple studies, with shifts toward a more student-centered practice, but only in high income schools. Theory is developed to define the resultant outcome/mechanism/context (O/M/C) relationships, then tested and refined through the review of each additional study.

As I often do in the kitchen, I already want to meddle with the recipe and reword the aim. Taking into account that teachers make choices in shifting their practice (Coburn, 2004), and that these choices are guided by context, conditions, capacity, and internal predilections, the aim of the proposed realist synthesis becomes ***to consider the mechanisms which mediate how different approaches to PD interact with existing conditions, capacity, incentives, and proclivity, to engender particular shifts in instructional practice.*** I welcome advice regarding additional ways to approach this vexation. Is a realist synthesis the appropriate approach? Can it take into account research that rests on a spectrum of theoretical and methodological assumptions? What can be done about the fact that there are assumptions underlying a realist synthesis as in all other approaches to research? The focus of the literature review also needs to be discussed. As a working definition, instructional practice refers to reform based teaching focusing on student-centered instruction that engages student sense-making, rather than teacher focused, knowledge memorization approaches. Although such practices correspond to NGSS definitions (NRC, 2012), this term would benefit from further discussion regarding the appropriate focus and bounding. For example, I am hesitant to narrow the search to science PD and instructional practices because science implementation and professional development literature does not often draw on key policy and organizational literature. However, the reform objectives of any given PD will likely have a strong effect on what PD approaches seem effective. (In conducting their review of the literature on effective PD for accountability, Hochberg & Desimone, 2010, may come to different conclusions than would a literature review on effective PD for inquiry in the classroom).

In addition, the second part of my venture still needs a recipe: How do I also interpret the findings to provide clarity for practitioners and policy makers who hope to change teacher science instructional practice? In metaphorical language, how do I create a meal that keeps hamburger helper aficionados and foodies in the same room, having a conversation? Like a meal, the need is a practical one: to synthesize the research across methodological and theoretical silos to present practical guidelines regarding teacher shifts in practice, toward greater learning opportunities for all students. I look forward to advice from the cooks from a variety of culinary traditions who are drawn to the Crossroads table.

"I can't teach that, I don't know the content!": How Content Knowledge Generates Deficit Thinking in Professional Learning Opportunities

Sara Heredia, ***Exploratorium San Francisco***

Vexation: Content knowledge as a singular ingredient

Disciplinary content is an important ingredient of professional development for science teachers. Indeed, a look through the literature on professional development for science teachers reveals the abundance of science professional development focused on developing teachers' content knowledge or providing them with experiences with "real" scientists. However, this form of professional development focuses on teachers acquiring the content knowledge they need to teach science effectively, rather than supporting teachers in understanding the role of content knowledge in their teaching and student learning. As we engage teachers with the *Next Generation Science Standards* (NGSS Lead States, 2013) and ask teachers to shift their classroom practices toward facilitating students' engagement with and understanding of science content through practices, we also need to shift how we think about teachers' content knowledge from something they have and acquire to something that they use in their work.

Professional development that only focuses on what teachers don't know perpetuates a deficit model of science teachers in that they do not have enough content knowledge to be effective science teachers and that with the proper understanding of science content they will be more likely to adopt and use reform science teaching practices. This deficit orientation towards learners locates the problem as internal to the individual and neglects the larger systemic issues that play a role in the organization of schooling (Valencia, 2010). A deficit orientation towards students has been shown to be detrimental for learning (Gutierrez & Rogoff, 2003) and could be similarly problematic in teacher education if we assume a constructivist learning approach for teachers (Putnam & Borko, 2000). Teachers, like students, have knowledge and previous experiences that can be leveraged for their learning and professional development opportunities need to make teachers' experiences salient for their learning.

Various researchers have defined the various forms that content knowledge takes for teachers as they engage in the work of teaching. In her review, Kind (2009) summarized science education literature over the past 25 years that took up the idea of pedagogical content knowledge first coined by Shulman (1986). Pedagogical content knowledge consists of the specialized content knowledge that teachers need to teach (Shulman, 1986). Various researchers have looked at the relationship between pedagogical content knowledge and content knowledge and tried to understand if they are separate bodies of knowledge or if teachers translate one into the other. However, I would argue that the relationship between content and pedagogical content knowledge is contextual and dependent not only on their students, but also on the features of the organization within which they do their work.

Often, researchers use interviews, surveys, and assessments to track teachers' understanding of teacher knowledge both within and outside of their educational contexts. However, all of these methods exist outside of the work of teachers and provide a picture of their content understanding in artificial contexts. Of concern in this proposal then is how learning is measured as we attend to content knowledge in use as teachers engage in their work, rather than as something they have acquired from participation in our professional development.

Venture: Content knowledge prepared three ways

A different way to frame science teacher learning is to understand how teachers come to make the decisions they do when implementing reform-based teaching practices in their classrooms and what role content plays in that process. In order to understand this process, I draw on the concept of sensemaking from organizational theory (Weick, 1995). Sensemaking is the process that individuals within an organization, like a school or a district, go through as they work to interpret and act on changes to their work environment. As teachers receive information about reform science practices, they focus on a particular aspect of the reform, attempt to connect it to their past experience as a science teacher and work to think about how to change (or not) their current practice to align with the new one. In essence, we could imagine that as science teachers engage in this process their scientific understanding is one of the many resources they draw upon to make sense of that reform. Therefore, it is less about what knowledge they have and more about how they go about leveraging that understanding in interpreting and acting on changes defined through reform for their students in their particular organizational context.

"I can't teach that, I don't know the content!": How Content Knowledge Generates Deficit Thinking in Professional Learning Opportunities

Sara Heredia, ***Exploratorium San Francisco***

As we shift our focus from what teachers know to how they use what they know, we can listen for what the content needs are for teachers as they engage in sensemaking around reform-based science education. In this way, we no longer assume what science content is necessary for teachers, rather we listen to what needs arise in their sensemaking process and in turn make their content learning consequential for the practice of implementing change in their classrooms.

My research into science teacher learning and use of science content takes place at the Exploratorium, a hands-on science museum located in San Francisco. The Exploratorium's Teacher Institute provides professional development for middle and high school science teachers from the Bay Area and beyond. Teachers apply to participate in a three-week summer institute that focuses teachers on engaging in hands-on science activities based on exhibits on the museum floor. After their participation in the summer institute they become alumni and can attend Saturday content-based workshops during the academic year or one week alumni institutes over the summer.

In the summer of 2015, we started a two-year DR K-12 exploratory research project of teacher alumni participating in a one-week summer workshop and follow-up Saturday workshops. The project is designed to support teachers in modifying the activities they engage with at the Exploratorium into practice-rich science investigations for their students that align to guidelines outlined in NGSS (NGSS Lead States, 2013). In particular, the activities centered on the crosscutting concept of *Energy and Matter: Flows, Cycles, and Conservation.*

During the summer workshop, teachers spent the morning sessions engaged in the activities themselves as science content learners. Then, in the afternoons we supported them in crafting a series of lessons for their students with that particular activity. The goal was that teachers would, over the five-day workshop, come up with a series of lessons that they committed to implement during the 2015–2016 academic year. As expected there was variation in the selection of activities and lessons designed by the teachers, as well as differences in the content supports each teacher needed as they modified activities to align with NGSS.

The work will continue over the school year with four Saturday workshops, two of which will focus on sharing and interpreting data that teachers bring from their implementation to learn from their students how they need to change and adapt future lessons designed for three-dimensional science learning. One Saturday workshop will continue the work of adapting lessons with a new group of teachers and the last Saturday will provide an opportunity for teachers to share their work with other science teachers in the Exploratorium community.

As far as the role of content in teacher talk during these workshops, I have an opportunity to analyze the ways teachers leverage similar content in three different types of activities. In the morning during the summer workshops teachers were active learners of the content as they engage in the practice-rich investigations themselves. In the afternoon activities, teachers leveraged their understanding of the topic to develop a series of lessons based on a coherent content storyline that they developed. In the follow-up Saturday workshops, they will talk about the content through the lens of their students' conceptual development during the lessons.

The sources of data include videotaped teacher collaboration in each of the activities listed above, focus group interviews, artifacts from their participation in the workshops, journal entries written after implementation, and copies of the final set of lessons they implement in their classrooms.

Areas of potential conversation in the incubator groups:

- In what ways do teachers' histories of participation in science and schools shape their understanding and use of science content in their work?
- How do we meaningful measure teacher content understanding so that it informs teacher educators in ways that will help us design productive learning opportunities for teachers?

A Recipe for Success

Cheyenne Herland, ***DaVinci Academy of Science and the Arts -- Ogden, UT***

Vexation

MY VEXATION AND VENTURE IS A THREE-LEGGED DINING TABLE OF FOOD-FOR-THOUGHT. I ask you to envision three sample platters of vexations on top of the table, one above each leg, and to see the legs supporting the table as the venture I propose. The tabletop represents the teachers who will drive change in their classrooms, with the goal of working smarter toward critical-thinking, 21st century college-ready citizens as graduates.

Snack on this from platter one: Students are often asked to learn about how others do science by going through the motions using pre-fabricated labs. Doing science this way is a rote learning practice of performing pre-assigned tasks in a specific order, using pre-determined materials and methods without deviation. Like making boxed macaroni and cheese, this modality doesn't demonstrate the kind of creativity sorely needed for authentic learning engagement. Typically referred to as "cookbook labs," pre-fab science is far worse, as once I've tried a recipe "by the book," I can decide to deviate and individualize it to my own liking in subsequent creations. Pre-fab science does not communicate the Scientific Process as a recipe for inquiry; simple guidelines for decision-making that enable solid science practice and accountability. Instead, this formula yields students who keep scientific processing separate from the happenings of "real life" or decide that science is too rigid or boring. Opening up the pantry, giving some basic guidelines for creating one's own recipe, opens up the conversation to the possibilities that occur when students challenge their teacher and their own limits. Teachers in professional development share about their fears of disorder during outdoor and messy labs. Inquiry methods with an element of freedom and student choice are seen as a time waste that keeps them from dishing out more of the curriculum on schedule. Subjects that could complement each other beautifully – like the chili powder and sea salt I sprinkle on top of my homemade brownies - are often seen as rigidly compartmentalized into their respective departments. Interdepartmental competition is sadly common, yet including music, art, writing, nature exploration, and students' own passions and talents as a vehicle for teaching science makes it relevant and fun. Scaffolding labs utilizing the iterative process raises scientists, rather than regurgitating robots who make a mean boxed meal.

Platter two offers the following bitter dish: Students aren't spending enough time outside, and in my experience see themselves as "other than" or above nature, rather than a piece of the ecological puzzle. Before becoming a formal classroom teacher three years ago, I spent five years as a Utah state-certified environmental educator teaching at Utah's oldest nature preserve, then one year as the science specialist at our local environmental magnet school. I have written and facilitated school science field trips as well as summer camp science learning experiences for the preserve and for Weber State University. Comments about being made to stay indoors, not being allowed to go out to play, or preferring to play or learn indoors, as well as many concerns about the safety of the outdoors have been common themes in conversations with students in all settings in which I have taught.

Platter three offers tidbits with plasticine and metallic undertones: I have experienced first-hand the terrors of technophobia. Looking back after two years of dedicated technology study, I can now see that I work so much smarter and have empowered my students with technology tools I didn't know existed or was too afraid to use before. I have seen my coworkers' faces redden and eyes glaze over when they don't understand how to utilize a piece of technology. I would estimate that 85% of my students have miniature handheld computers in their pockets. And yet, we do not allow use of personal electronic devices, school-wide. Students mainly see their phones and iPods as toys, rarely as tools to empower learning success. Internet bullying, sexting, online plagiarism, and other very real concerns of the netiquette variety are common. Parents don't seem to be setting boundaries for or supervising their children's internet usage, nor are kids being encouraged at home to see electronics as professional tools for ICT.

Inquiry that is driven by hands-on, cross-curricular, indoor and outdoor teaching methods and utilizes ICTs to access a world of information, empowers teachers and students to be engaged together in a community of learning. Offering the whole curriculum and cross-cutting concepts as the menu of raw materials we have available to us allows us to open up the inquiry to our students' creative palates. "We'll be making something savory today (testing chemical change). What do we want to use to cook up something wonderful?" Like adults, students learn better by doing. They want to get their hands dirty by rolling up their sleeves, kneading it all together, and letting the flavors meld and complement one another. Then, and only then, can they really beam as they take ownership and serve up their learning, "Look what I made!"

A Recipe for Success

Cheyenne Herland, ***DaVinci Academy of Science and the Arts -- Ogden, UT***

Venture

THIS YEAR, IN ADDITION TO TEACHING 4 SESSIONS OF 8TH GRADE pre-AP Integrated Science and one of 7th, I am now the Educational Technology Specialist at our charter school, DaVinci Academy for Science and the Arts. My principal has freed up a second non-teaching hour for me, in addition to my prep period. I'll be starting small this first year, taking inventory of the tech we have on hand, learning how to use it, as well as learning and teaching new technology. I will design all-staff trainings and work with individual math and science teachers to implement technology into one lesson plan each month, with the goal of using it to help them work smarter, free up time, and embrace hands-on inquiry methods. I will be working to improve our School Technology portfolio, and with the Technology and Curriculum Development Committees.

The timing of this new opportunity is right for me to begin designing my thesis research in the fall, as I work toward an M.Ed. at Weber State University. I want to study the ways that implementing ICTS empower an ecological-teaching philosophy that includes authentic, hands-on inquiry and cross-curricular teaching. And I want to study the effect this 3-legged table has on both students and teachers, as it relates to student work, teacher and student experiences of success, satisfaction and community-building.

To pull this off as admirably as I'd like, I need guidance determining how to share technology in a way that doesn't terrify grownups and honors them as the lifelong learners they are. These trainings need to be taught as teachers have the technology in front of them and can follow along and do as they learn. Teachers will be responsible for providing evidence of their implementation and samples of student work, as well as completing both student and teacher surveys at the beginning and end of the year. I want teachers to feel that I provide support and solutions, rather than that working with me is one more thing they "have to do." I want them to begin to see technology and inquiry as vehicles to drive the curriculum. I want to leverage technology to encourage more outdoor class time and to free up time to look at how they can implement more inquiry-based methods, across the curriculum. And I want tools for responding gainfully when teachers refuse to see change as anything other than forced torture and invalidation of their best practices, regardless of my best efforts.

I would greatly benefit from direction toward studies, papers, and similar good work being done as I prepare to design this research. Especially coaching that pertains to working with adults, engaging them in tasks they don't want to do or perhaps fear, and about designing research in a way that will compliment and utilize my new position.

Leo Tolstoy said, "A person who has spoiled his stomach will criticize his meal, saying the food is bad; the same thing happens with people who are not satisfied with their lives." Education can be a joint adventure, experienced within a learning community where it is safe to risk, to respectfully challenge, safe not to know the answers, but to know how to go about finding them together - empowered by all of the tricks of a 21st century educator. It's our responsibility to build community and our own knowledge so that this kind of learning is possible. The image of a three-legged table is a potentially unstable one. So it is with the messy, unpredictable, evolving exchange between teaching and learning. The stabilizing ingredient in this venture is the relationship we build with our students, their trust in us, and ours in them, as learners. We are all taking risks here; it's the only way to ensure a toothy sense of satisfaction in our work.

To be good sous chefs, to prepare the Science Kitchen Theatre well, is to encourage our students to create something great. Our role then switches to head chef, watching over their shoulders as their own understanding of how things work deepens, and their confidence grows because their hands are in it - they see and feel it working, and to the best of their ability they understand why. It's our job not only to cook up something grand ourselves, but to learn the latest methods and technology, that we may authentically inform and inspire the chefs of tomorrow.

Geo-Fluency and Social Media as a Platform for Student Advocacy

Jenny Ingber, *Bank Street College of Education*

Vexation

In the past few years, experts have been contemplating the term "anthropocene" to describe the current epoch in Earth's history and have been attempting to determine when to define its beginnings. It is suggested that the anthropocene would mark the time in which human activities began to have a significant impact on the Earth and its inhabitants. Scientific evidence has been generated to build a substantial case that humans have, in several different ways, altered both local environments and global systems. Consequences of human actions being seen include: climate changes which have moved the ranges of certain species and has decimated populations of others; increasing of the amounts of plastic which is floating along the surface of our oceans and is entangling or is consumed by sea creatures; redirection of waterways which is impacting the surrounding habitats in a multitude of ways; among others. All members of today's society contribute, in some way, to the altering of the Earth. However, not everyone understands the implications of their actions. Even fewer understand the underlying scientific concepts that can be used to make thoughtful daily decisions and help to advocate for solutions to minimize human impact on the environment. I have been attempting to define a construct I am calling ***geo-fluency*** to describe the knowledge and skills that a person needs to both make informed decisions and also to be able to articulate and advocate for specific decisions and/or solutions that he or she believes would benefit his or her own lives and communities using his or her understanding of an environmental issue and the underlying scientific causes of that issue.

While there is building interest, concern, and tools for encouraging people in American society to be better stewards of the environment and advocates for environmentally-friendly decisions through K-12 schooling, there remain questions and debate about the extent to which K-12 learners really have disciplinary knowledge of the underlying scientific idea that can inform good decision-making, derive or support solutions, and advocate for the environment. Within the *Next Generation Science Standards [NGSS]*, K-12 education is perceived as a venue where learning science can be used to support understanding in this area (NGSS Lead States, 2013). The NGSS have established performance expectations for K-12 students to demonstrate their "three dimensional" understanding of science and engineering. As new curricula are being developed to attend to the NGSS, students will be engaging in "science and engineering practices" in order to both learn and demonstrate their knowledge of "core ideas" and "cross-cutting concepts" – in essence building science disciplinary knowledge. This requires the developing of both knowledge and skills for learners within the context of school science. What remains is the additional layer of connecting these ideas to the specific societal concerns about the environment and the skills required to both make decisions about and advocate for solutions that can minimize human impact on the Earth and its inhabitants. What vexes us about this scenario and the use of K-12 schooling for supporting students/citizens understanding and taking actions resulting from understanding of science as well as understanding the implications of human actions on the Earth and its inhabitants are as follows:

What kinds of understandings and skills do the general public and/or students need to have to become "geo-fluent" and make everyday, and community, decisions that have environmental implications? And, how can we support student learning in K-12 so that they understand the following to become geo-fluent citizens as adults?

a) The scientific phenomena relating to human altering of the environment (e.g. How will the Earth or its inhabitants be affected by the decisions people make? What are the scientific principles that allow us to create models or hypotheses about the outcomes of human actions?)
b) The implications of human actions on the environment?
c) Strategies for gaining a robust understanding of the complex ways in which humans are affecting the environment (e.g. creating and testing of models, field research, etc.)?
d) Tools for identifying the range of concerns relating to these effects from both an individual and a systems perspective? And,
e) Skills in being able to make decisions and also to argue and advocate for good solutions?

I am suggesting that before I can begin this work I need to first unpack big ideas typically taught in K-12 science and social studies that lend themselves to the development of a "geo-fluent" community who can make decisions and support solutions while considering the implications of these solutions on the environment and on the community. I am also considering the community, as a whole, needing to be "geo-fluent." However, I need to acknowledge that if not all members of the community are actively participating in the decision-making, we should determine what is most important for K-12 students to learn before they leave high school. I find myself asking: How much do the individuals who aren't making decisions for the community need to know in order to participate in the

Jenny Ingber, ***Bank Street College of Education***

solution? Is there value to having all of the members of a community understanding the underlying science of a problem? If so, what do they need to know in order to value and contribute to the decision and/or participate in the solution?

If I assume that all community members should have some level of understanding of the science and be able to *actively* participate in making decisions related to which solutions to adopt, and participating in the solution - if it involves individual participation. I, additionally, add the need to support students in being able to gain new information and obtain skills for advocating for what they believe is the best solution for their community – either local or global. If this is the case, then I need to identify content and cultivate strategies for supporting K-12 learners in developing the knowledge and skills to participate and advocate in their local and global communities around issues relating to human impact on the environment.

Venture

In order to address our questions, I am deeply considering both the learning experiences and the places in which learners can both demonstrate their understanding and use it to take actions. I would like to develop, in K-12 students, geo-fluency. This venture sets out to create a testable model of how ***geo-fluency*** might look in K-12 schooling and/or in educating the public. The challenges with this are multi-fold, as it is about defining different aspects of geo-fluency, as well as determining the ways in which individuals can demonstrate their geo-fluency through their actions.

Geo-fluency involves having a complex understanding of global environmental issues and language to articulate what the problems are, why they exist (especially the underlying science), potential solutions that take into consideration societal needs and human systems, and being able to make informed decisions and then advocate for those solutions/decisions.

What I am suggesting is that there needs to be extensive attention paid to the science content and have this content be leveraged to both make personal decisions and within the context of the argument and advocacy of a societal decision or for a particular solution to an environmental issue. I want students to learn how to be compelling to others, to deliver their message in an accessible way, and to integrate their science learning as they advocate for a solution. Individuals may take a stand on a variety of issues and communicate their ideas, but fail to ground what they are saying in science. Oftentimes, it seems that the general public may be aware of the *consequences* of human decisions, but are not necessarily as well versed in the *scientific phenomena* that explain the *causes* of those consequences. Additionally, I am claiming that the practices involved in gathering and synthesizing information and delivering the message to wide audiences – in an effort to advocate - need to be taught and practiced within school learning experiences and can be used as tools for the assessment of learning the science and, in turn, growing the students' geo-fluency.

I additionally propose that, while there are several mainstream platforms that are available to the general public that can be used as tools to advocate for decisions and solutions, rarely is it apparent the extent to which arguments in these forums are evidence-based or scientifically-informed, if they are at all. This is problematic, as science then may be presented as a body of facts or information may be offered that is not based on empirical evidence – both of which may create confusion or mislead the public.

The model I am working from attempts to take into account the learning and actions that seems to be necessary for demonstrating geo-fluency, from my perspective. It only begins with an understanding of the science as described in the NGSS. Knowing the science is important, but knowing the science in the context of the issues that society faces on local and global scales is also essential. At the same time, it needs to be acknowledged that avoiding problems are not solutions and that societies have needs that drive decisions. People need power, water, cleaning supplies, minerals, space/homes, etc. and those needs create disturbances to the environment – so acknowledging these needs is critical to making good decisions and finding solutions. This approach is antithetical to the alarmist way that many environmental issues are communicated, but would likely lead to more rational and more agreed upon solutions. Combining knowledge of the science and of the social systems would allow for the design of better solutions and more informed decisions – on the individual level. Helping individuals become more well-versed in tools, such as social media, to communicate, argue, and advocate their ideas, solutions, and decisions about a certain issue, would establish a basis for more wide-spread community (both local and global) considerations about how to address the issue. Learners need to gain skills in how to use these tools effectively as well as what needs to be communicated in these venues. If it became more commonplace to provide more substantial information about the evidence or the science that relates to a problem, then the broader public will have a greater expectation for the quality of their information sources and higher quality information to use when making their own decisions or designing their own solutions. Ultimately, a geo-fluent public, one that knows how to use science, in relation to societal needs, to inform their decision-making/solution design and effectively advocate to their community, will come up with more improved remediation strategies for minimizing human impacts as we continue our lives in the anthropocene.

Vexing Questions about Gender, Race, and Underrepresentation

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

Last spring, my good friend asked me: Why does St. Mary's College hold Math Girls Day for middle school girls? Girls and boys perform comparably in math on the NAEP and other measures. Why do we need an event just for girls? Doesn't this simultaneously send the message that girls need remediation, while also excluding boys from a fun, engaging opportunity?

At first I found his question exceptionally vexing, on all sorts of levels. First, it was illogical–how could the same event demoralize girls by including them and demoralize boys by excluding them? Second, it sounded too much like people who say "but if we're going to have Black History Month, shouldn't we also have White History Month?"– a failure to recognize that in many classrooms every day is Math Boys Day. But my friend has shown his commitment to equity and justice over and over, through his concern with all kinds of students, his commitment to improving his pedagogy, his determination to help students learn to teach all the kids they will find in their classrooms. Plus he's my go-to guy for educational psychology: He OWNS the field. If he has concerns, they're worth paying attention to.

I sent him a couple of articles (see below) that related to his question, but I wasn't satisfied. I've been living and breathing this field for decades and I couldn't answer the question coherently. The best I could do (and it wasn't too bad, but it wasn't what I wanted) was this:

> *Women are under-represented in STEM majors and STEM professions; the more mathematical the field, the more under-represented. This doesn't seem to be from lack of interest (I think) or lack of ability (I indignantly assert), so maybe it's because girls don't feel like they belong in math even if they're good at it.*
>
> *Thus, it seems to me that a special day for self-proclaimed "math girls[1]" couldn't hurt, even if a few boys feel excluded along the way. I would have liked it, and it's enthusiastically supported by women math professors and majors, so that's something.*

This isn't exactly a ringing endorsement, grounded in incontrovertible evidence, is it? Also, I realized that even if we believe we should encourage girls and women in STEM, we don't really know what works. These are fundamental questions to my work–why should girls get special treatment if their test scores are the same? And what kind of treatment works? I need to be able to answer them, and right now I think my answers are weak.

Then, in August, I'll be damned if the same thing didn't happen again, this time adding race to the mix. I was at a conference, watching Mia Ong and Apriel Hodari present recent work on the experiences of women of color in STEM majors where they are most under-represented (physics and astrophysics, computer science and some branches of engineering). They were talking about the common experiences and strategies reported by women of color who are persisting in these fields. They had a slide showing the plunging proportion of women of color graduating with degrees in computer science since the mid-2000s. A Black computer scientist working at NSF pointed out that the proportion of women in general among CS graduates has been plunging, and asked why it makes sense to single out women of color for particular study. My mental reaction was "WHAT??? Isn't that OBVIOUS?" But of course it isn't obvious; it's an argument he has to make to his colleagues when evaluating grant proposals, it's a basic argument that anyone studying equity in science should be able to make, and yet again I felt flummoxed by it. I don't know off the top of my head whether the proportion of women of color majoring in computer fields has dropped more quickly than the proportion of women overall; but I also am not sure whether I think that matters or not.

And a third anecdote: I have been looking at the proportion of women who graduate in physics, math and computer science at my little college (44% women from 2000-2012), compared with national data from NSF (27% women). Is this fantastic? Or merely less disappointing than the national pattern? Maybe it's an accurate reflection of the number of women vs men who want to major in these fields? Evidence of systematic discrimination, but less intense than at other institutions? What is our goal here? How would we know if we're successful at eliminating the obstacles to women's participation in STEM fields?

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[1] *My friend learned about Math Girls Day from reading about it online; I think he heard it as "math GIRLS day," as in math day for girls, when in fact its creators think of it as "MATH girls day", as in day for self-identified "math girls." In fact, boys aren't necessarily excluded, under this second reading; they are simply required to swim against the tide of patriarchy and identified with the feminine–as a 'math girl' or an enthusiastic supporter of math girls–in order to attend. Kind of like a program where I used to work, designed to rectify the under-representation of people of color in the sciences. White students weren't excluded from the program; they just had to be willing to participate in a program with "minority" in the title.*

Vexing Questions about Gender, Race, and Underrepresentation

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

Here is what I would like to see happen in my incubator session. I want us to all step back, and try to see our field from an outsider perspective. I want us to back up to first principles, and try to sketch out some basic answers to fundamental questions that I think I should be able to answer simply and elegantly, and yet, lately, …can't. My first draft of this venture had many many questions; Adam and Nate wisely pointed out that incubator sessions only last 35 minutes and I had hours of questions. So after a lot of thought, I've picked out my favorites. I hope you all will help me really pull these apart, explore answers that would be compelling to a wide variety of audiences, not just generate the same pat answers that don't convince my good friend David or the colleagues of the guy from NSF (or, really, me, for that matter).

1. Why do we care about under-representation of women in STEM? I don't want arguments about the need for more STEM workers; I want some thing more fundamental. When is under-representation a problem, vs. just a manifestation of different interests? What counts as under-representation? What about when a group is no longer under-performing at a particular level (as in the math girls question)–should we still be paying attention to them because girls like them (but older) are under-represented further along the career path?
2. Speaking of which–what forms of "paying attention" actually work? If we were charged with using well-supported evidence to design a school or program or something to increase the retention of women in STEM, what principles would we use to design that thing? What do we think the nature of the problem is, anyway?–since our idea about what's wrong will direct us to what steps to take to fix it. How would we know if our program is successful?
3. And (assuming we decide that under-representation matters and is worthy of attention) if we find that women of color are performing no different from White women in a particular discipline and career stage, should we no longer consider them separately from other women? (Yes, I know about intersectionality–I'm asking if there's a point at which intersectionality no longer needs to be taken into consideration, or if there are deeper philosophical reasons for always thinking about intersectionality even if there are no differences in outcomes among groups).

I'm worried that I'm still asking far too many questions; I hope that simply by hearing folks talk these out in an incubator session, I will get good ideas. My session last year helped me resolve a major question plaguing me (when I look into the STM departments at my little college, can I look at biology the same way I look at chemistry, math/CS, and physics? Answer: No. Biology has more students wanting to major than it can handle; chemistry is kind of resource neutral; and math/CS and physics are eagerly trying to recruit people to major in their departments), which in turn led to a beautiful moment during a yoga class this summer when my sabbatical project finally (months after receiving approval for it) bloomed fully-formed in my mind. May this year's session be similarly fruitful!

Note:

These are the articles I sent my friend after our Math Girls discussion–note that a) the list is dated, b) the list doesn't actually answer my friend's question at all–it just shines light on the question of how girls could do well on NAEP but not go on to pursue careers in math-based STEM fields:

Brotman, Jennie S., & Moore, Felicia M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching, 45(9), 971-1002*.

Carlone, Heidi. (2004). The cultural production of science in reform-based physics: Girls' access, participation, and resistance. *Journal of Research in Science Teaching*, *41*(4), 392-414.

Johnson, A. (2007). Unintended consequences: How science professors discourage women of color. *Science Education*, *91*, 805-821.

Johnson, A. (2012). The mathematics of sex: How biology and society conspire to limit talented women and girls. (Review) *Science Education*, *96*(5), 960-962.

Ambiguity, Anxiety, and Insecurity: Building Confidence through Ripping

Eugenia Johnson-Whitt, ***Walsh University (Canton, Ohio)***

Vexation

If unprepared, junior faculty in academia face challenges that leave them unable to assist their students (Jones & Osbourne-Lampkin, 2013) in learning the process of writing scholarly. The challenge of writing makes me feel unprepared in guiding students toward scholarly writing. I graduated from a predominately white institution that adequately supported me through the doctoral process – but inadequately prepared me for the writing skills required to secure a tenure track position and obtain tenure. The only person I found solace and comfort in sharing my writing was my advisor whose review and revisions on my writing provided much needed constructive criticism. He provided ways for me to grow in writing and suggested for me to write, write and write more to gain more confidence. I found ease in sharing my inadequacies with my advisor because he looked and talked like me. He shared with me his writing failures and successes. Understandably, he had teaching commitments, research, and other students to advise. So, I needed to find other ways to learn the process of writing. Additionally, I took a writing course where the professor knew how to make me feel proud of my writing. Both of these individuals knew how to scaffold my learning the writing process. Only this support was inadequate to support me through writing my dissertation. My white doctoral colleagues struggled as well. However, they seemed to have access to or skills to find resources that scaffolded them through the writing process. These resources and skills were absent during my preK-college education. Additionally, my white doctoral colleagues had experiences that provided them with skills or resources to find tools. As a result of inadequate support, I found writing my dissertation boring. My dissertation was my best piece of work in terms of research, but it fell short regarding the scholarly writing process. I was unable to fully express myself.

On the outside I walk, talk, look and assimilate the role of an academic scholar. Yet, deep inside I found myself struggling to conform to the writing quality of my colleagues. This led to a feeling of deep regret and with me almost dropping out of the doctoral program. The process of scholarly writing seemed sterilized of emotion and subjectivity. Finally, through a friend's relative I found the help required to move my writing toward lasting quality. My friend's relative did not have nor was working towards a doctorate but Luna's [pseudonym] ability in mastering the English language in writing was excellent. For about 3-4 months we met weekly. Each week, Luna ripped my writing style and format into shreds. I accepted each rip with gratitude and dismay. Through the ripping process, I learned how to write and determined what to expect from writing scholarly. I triumphantly completed the dissertation and received my degree. If I am able to complete the dissertation surely I can assist others through the process. Yet, the challenge in writing scholarly is not over. Now, I need to write about my research agenda in order to obtain tenure. I will need to help student advisees. How do I effectively acquire resources to represent my research for publication and funding? Who can I trust? How can I facilitate assimilation of the academic research community's writing style and format or should I?

After completing my doctorate, I accepted a post-doctoral position at a major Midwestern university and found my writing skills were better than expected. As I reflect, my writing had an impact on me because I wrote so much during and after my graduate program. Many of my graduate students in my new role requested and needed my help in writing. Ironically, I found errors on students' papers and provided feedback. In providing assistance and offering constructive criticism on students' papers, I learned more about writing and the process of scholarly writing. Many times I found myself envious of the writing skills of senior faculty [including my advisor]. Finally I accepted the fact I needed to write more to write better. So I did. Many times, colleagues reviewed my papers allowing me to garner more experience in the writing process. As expected, my ambiguity, anxiety, and insecurity went up and my self-efficacy went down. Now is the time to get past the envy and move on to accept the challenges.

Ambiguity, Anxiety, and Insecurity: Building Confidence through Ripping

Eugenia Johnson-Whitt, ***Walsh University (Canton, Ohio)***

Venture

Often we have a sense that asking for help is admitting vulnerability or failure. My fears and struggle in writing is not necessarily a negative position, but can be a way to see the richness and the freedom in guiding my work as a scholar (Jones & Osbourne-Lampkin, 2013). How do I accept a peer's feedback without feeling failure and yet grow professionally? I must learn how to move from the ripping process and grow. I have realized I need a trusted colleague to provide another set of eyes to see what I cannot and provide the necessary feedback. Asking for help does not make me unqualified, but makes me human.

There are many factors that impact my self-efficacy towards writing. My self-efficacy in writing stems from culture, age, race, background, and lived experiences. I, like many urban students, see very few people like myself to ask for or to find help in my academic community. Writing scholarly is extremely tough for me, I cannot get the job, promotion or tenure if I am unable to write. The ripping process is a major part of peer reviewing in journals. The process will become easier and I think the value of outside feedback is never diminished.

I have not reached this stage of my career without overcoming obstacles. So the first step, with fear in my fingertips, is to write about the challenge of writing scholarly that myself, and a number of students experience in the academic world. Secondly, I accept to go through the ripping process with a smile. Thirdly, I will push my students to write better, as the struggle to write scholarly is universal. In talking openly about the challenge of writing scholarly the process will be less daunting for individuals with few or no scaffolds. I know my fear toward writing will not disappear but my confidence will build and grow into becoming a better writer. In order to build my writing confidence, I commit to the following goals:

1. Submit and write about my fears and challenges with colleagues who will offer support and resources
2. Apply to be a grant reviewer to read and to comment on the writing of others
3. Complete and submit an article on my research agenda for a peer review journal.
4. In my new faculty position, teach an undergraduate course with an emphasis on writing scholarly for students to participate in research.
5. Participate in a writing group and assist in completing a book chapter or journal article.
6. Develop a culturally relevant high school unit on forensic science and share the findings with the science education community.
7. Submit an application to the National Science Foundation's (NSF) for the Early Career award using the forensic science research or creating a writing workshop for people like myself [underrepresented populations] to learn the process of writing.

As I research, write, teach, as part of a team, [***we***] all will learn to write better and more scholarly, thus, allowing our voices to be heard. More support and research on how to equalize the playing field for underrepresented faculty at the institutional or departmental level should be considered

Physical Science for Elementary Teachers: Multi-course meal or potluck?

Adam Johnston, ***Weber State University***

Vexation

This fall, after a year-long sabbatical, I get to go back to my classrooms. In fact, I've recently realized that this is the first time in six years that I'll return to my full teaching load, no longer burdened or distracted with administrative assignments of various flavors. This has given me a renewed energy and enthusiasm, in spite of the 4-course responsibility each semester. I've pulled up class rolls and even the photo rosters; I get giddy considering all the faces, all the ideas, and all of the new conversations we've yet to create.

My typical responsibilities flux between general courses in physics and very specific courses in science education. This coming term, in particular, reads more like a diverse four-course meal (or perhaps a church potluck) than four courses. There's a general physics course, a typical offering for pre-med students, that meets daily in the early morning. A weekly science teaching methods course is offered on Wednesday evenings. On Tuesday and Thursdays I co-teach with a friend from English for our Honors Program. And to further mix up the casserole there's Physical Science for Elementary Teachers. It meets twice a week for class discussions, with a three-hour lab slot each Thursday afternoon.

In all of my classes I think about many of the many things any other Crossroads reader might bring to mind. How do I engage students? How do I address misconceptions? What are these students' views of science itself, and how do they analyze data and craft arguments? What are my goals for these students in the first place? And on, and on. This is the fun of it all, really. And it's not any inconvenience to scrap things I've done before, even if they seemed successful in one way or another, in order to look for a better outcome for students – or even for my own entertainment. In no other course is this more true and, I think, more critical, than in Physical Science for Elementary Teachers.

The Physical Science course is perplexing to me probably because there are so many possibilities in the science content, the pedagogy, and the goals. It's a one-semester course with no prerequisites and no significant credential for other courses beyond the fact that it gets these students some general education credit. They take this science credit instead of another required by the university simply because it's advertised to be relevant to them. (There are similar courses in Life and Earth sciences taught in other semesters by colleagues of mine.) So, as long as I make sure the objectives of the course match our general education standards (which simply include basic objectives about forces, energy, matter, the nature of science, etc.) and satisfies the advertised claim that it's for future teachers, I have many opportunities to improvise the recipe.

While this is nominally a course about the basics of physics and chemistry, what stuff is made of and what it does, I have other critical side dishes. It's entirely possible that these students will see no other science course that offers them explicit ideas for their own classrooms, so I think it's important to give them touchstone experiences to build from in that regard. These students generally take very little science and often are intimidated by the content, the portrayal of science, the potential for mathematics to be used, etc. So, I think it's necessary to help change attitudes and expose these students to new combinations of flavors that could be appealing to them once sampled. And, I want these future teachers to see how multiple concepts in science can be integrated across scientific disciplines and beyond. I need them to see that ideas in science are not sitting in isolation from one another nor from a broader context; that scientific knowledge is more than knowing about a fact or even remembering some equation for the magnitude of a force, and that a scientific practice is not just about a scientific method or an experimental technique. In short, I want them to start to embrace a broader view of science, similar to my developing understanding after 20 years in the field. They have 15 weeks.

Additionally, it's no secret that science reforms I embrace are on these teachers' horizons. Across the nation, and even in our own special corner in Utah, we're working to implement science standards that are at least based on the same three dimensions as *Next Generation Science Standards*: disciplinary core ideas, crosscutting concepts, and science and engineering practices. It would have always been irresponsible to design a course that says "this is what you'll teach in fourth grade," because that's narrow and limiting. Now, it would be even less palatable because there are many more possibilities and much deeper principles that they'll need to understand.

So here's all that's going into the mix: I'm emerging from the sabbatical in which I've gotten to think about lots of alternatives to the teaching scenarios I'm accustomed to – too many to describe here. I'm tackling a class that I dearly love and love to play with, but am also always perplexed by the many possibilities in limited time. And, I'm dissatisfied with a traditional physical science sequence and focus that can be narrow and piecemeal; I'm looking to bigger ideas of what science is that can help these future teachers be empowered to embrace science in multiple contexts. In light of all this, I've decided to do something relatively bold that I can't undo.

Venture

After years of helping to organize *Crossroads*, I've learned that ventures come in three categories. There are the dreams, the things we propose because you have to give them a chance to start, even though the likelihood of them manifesting in a way that is anywhere near what they were originally envisioned is only about one in a hundred. There are the bold moves, those steps forward on a project that take a new, unanticipated path – but with capacity and energy to forge ahead. And then there are those projects that must be done, bold or not – as though there are guests all coming to my table and I need to make sure that the places are set and the meal is prepared. This venture is the last of these types. I have to move forward, but I clearly have choices about how to prepare the meal. Soup or salad? Will there be multiple meat options? And can I accommodate my gluten intolerant friends? And should I?

Physical Science for Elementary Teachers: Multi-course meal or potluck?

Adam Johnston, ***Weber State University***

In pushing myself to make a change to this class, away from the traditional table of contents of a traditional course, I've decided to abandon the long-used, very standard text I inherited and have continued to require of my students. In fact, the text was never ordered by the bookstore and will never be mentioned on the syllabus. I'm forced to create a replacement in one form or another. Although the book is easy to read and accurate, it portrays science in a way that is counter to what I'm trying to get across. It begins with a chapter on "what is science" or some such thing, then steps politely into motion, then into forces, and on and on. It was designed, essentially, so that it could be adopted for lots of purposes, and one could skip around and teach from the book in an a la carte manner. My feeling is that, by removing this particular structure, I am forced to create my own course framework and focus, and possibly forced to create the beginnings of my own, in-house materials. (As I am drafting this piece, my 13-year-old was just praised by her mother for the lunched she'd prepared for herself: "That's the makings of a chef." Grace, being Grace (and 13), contested this, and claimed that there was simply nothing else that was any good in our pantry or refrigerator. I find myself in the same situation as my daughter. There's nothing good to eat anymore, in spite of all the food.)

So where do I even start? I'll begin by writing course notes to fill in as a text. My intent is to use that to organize the course into units that are framed around bigger ideas. Needing to create this text forces me to write out this narrative as I think it should be to meet the needs of these preservice teachers. In turn, this gives me the opportunity to really intently structure the course as I see fit. My first blush idea is to organize this around the NGSS Practices. Using these eight big ideas, I think that I could make the focus of the course be truly about what we do in science, rather than the piecemeal topics. At the same time, I could "cover" those other ideas that make up the standard menu of a physical science course (motion, forces, temperature, chemical change, etc.). The challenge here would be to make the course conceptually coherent. If I start with "Questioning" as the first unit, how does the rest of the physics and chemistry get organized as we move from there to investigations and to argument? I have vague ideas about exactly how this will work in my own course, but I laid out a plan to organize a sequence in which each of the eight practices would be tied to one of the seven crosscutting concepts (so one of these would be used twice). This order and pairings would look like this, with each of these "units" occupying a timespan of about one or two weeks: / Questions + Patterns / Investigations + Cause & Effect / Analyzing + Structure & Function / Computation + Scale, Proportion, and Quantity / Constructing Explanation + Energy & Matter / Modeling + Energy & Matter / Communicating + Stability & Change / Arguing + Systems & System Models /.

But here's what I realized as I've worked on something as simple as a sequence, schedule, and syllabus for the course. It could be that I'm becoming my own worst enemy, paving a road with good intentions. It's as though my multi-course meal is trying to make each plate its own theme, rather than finding the themes that reach between each appetizer, soup, and entrée. While I want to restructure the course so that there's an explicit and generally revolutionary shift in focus, I also realize that there's a reason for the liturgy of a traditional physics curriculum (thanks to Angela Johnson for reminding me of this). It's hard to motivate an understanding of energy if you have no concept for motion. In a similar vein, there's no unit on "questioning" without something to ask questions about; "Structure & Function" must be tied to the phenomena of some thing, rather than a topic that exists on its own without application.

So, I have advanced to Venture 2.0: In this version of my course structure, I could start with an extant set of labs and activities. (This would be a terrible idea except for the fact that I've embedded many of the scientific practices into these already, and they could be revised to emphasize these in new ways.) Those teaching episodes give me touchstones to tie other ideas to, and to which I can narrate both a text and a class. Although the labs are based on the traditional liturgy of a physics class (motion, forces, etc.), I can provide new narration to explain another context. And, in the long term, I could come back to those labs and revise them so that they better support the narrative I'm working on for the course. This also allows for me to lean on one current strength of the course, that it's driven by phenomena and my students' experiences. They get to taste first, then learn to cook.

I'm in the thick of this, but I'm looking for guidance and advice. I know this plea is too vague, so here are some specific questions:

- Even though I'll have already started this by the time we're at the table, I imagine that a lot of what I'll be doing will be malleable, and certainly this will be a design process that will be ready for changes for future semesters. ***What's the best structure to organize a course like this one?*** Do we shoot up the saloon or do we stick with a traditional multi-course meal? And what combinations or layers of structure should I consider for a course like this one? For example: I know I never mentioned using "disciplinary core ideas" in physical science explicitly, but I've thought about using those as organizing structures as well.
- I'm writing up course notes which inherently become a narrative of how I think of ideas that my students are grappling with in class. ***Thinking more broadly and longer term, what's the best format for this?*** Currently the project is being cooked up at <firstdrafts.net/physicalscience>, and all are welcome to poke at this.
- Elementary teacher preparation is widely varied, but I know that others grapple with the same challenges that I do: ***Elementary teachers could benefit from more authentic science and more empowering science teaching experiences.*** I would like to think that I bring some of this to the course (even though one semester can't be expected to do too much), but ultimately this becomes the central question of the vexation and venture. As I'm working on the logistics of the course and its text, this is really the driving discussion.

A Chef's Journey to Extend the Ultimate Dine-In Experience

Meredith Kier, ***College of William and Mary***

Vexation

MY HUSBAND AND I SOMETIMES MANAGE TO COORDINATE A LUNCH DATE DURING THE WEEK at this small Mediterranean gourmet market between our places of work. There's nothing pretentious about this market attached to a 7-Eleven gas station. It has large plastic chefs placed as tacky décor, and four wobbly tables with chairs placed beside the aisles of baked goods, olive oils, and spices to sit if you care to "dine in." This small, family-run business has a small kitchen in the back of the market where we place our order to a single chef who prepares fresh grape leaves, pickled vegetables, kabobs, meat pies and other amazing delicacies. The food is addicting and sometimes when I need my Mediterranean "fix", we place an order for carry out. While the food sustains my cravings, it just is not quite as good as dining in. Perhaps it's the warmer food or the family members charmingly yelling in Arabic across the market. Something is lost when the food is transferred from the market to our house, less that a mile away.

I feel that my students experience similar dissatisfaction to my Mediterranean food carryout when they take courses online. Historically, fewer students of historically black colleges and universities (HBCUs) enroll in online courses than students at Predominately White Institutions (PWIs; Flowers, White, Raynor, & Bhattacharya, 2012). One reason is that many minority students enroll in HBCUs because of the culture of personal interactions within these institutions, including one-on-one interactions with faculty members, and accessibility to mentors (the ultimate dine-in experience; Redd, 2012). As a former professor at an HBCU who taught science education and instructional technology courses, I had to be very mindful of this culture. My students had access to email and my personal phone number; I allowed them to have around-the-clock access to me (with a disclaimer of not being available after my 9:30 bedtime) for homework help and clarification questions. My students were very grateful for the effort that I took to connect with them. The connections I held with my students were very important to me, and I took great pride in it. My efforts were only reinforced when colleagues approached me to learn how to motivate our students and how to reach them better in class. I am the charismatic chef who can deliver the apricot and pistachio baklava with orange-cardamom syrup with a smile.

Knowing this, I was very nervous about teaching courses online this spring during maternity leave. After being the ultimate chef for the first five weeks of the semester (pre baby), I assured my students that I would still give them an excellent carry out experience online that included thorough feedback on every assignment and availability by phone and email to answer their questions. I could sense their hesitancy. I remember one student saying, "I'm just not good with online classes… I need someone else to hold me accountable…you can't do that as well online."

My daughter came into the world, the semester progressed online, and the majority of my students understood that I was still able to hold them accountable for assignments, provide feedback, send daily announcements via Blackboard, and respond to their text messages (even in the delivery room!). Yet by the end of the semester, I found that some of my students became uncommunicative and some put forth less effort than usual. For example, I recently received this email from a student in one of my classes:

> *Greetings, I haven't spoken to or seen you in forever! Due to the fact our class has been solely online with final semester approaching I totally forgot I even had an online class at all let alone about the assignment due this week and the remainder of the discussion boards. I had gotten so use to you posting reminders and announcements for assignments as they appeared. Are you not accepting any late work at all for the last assignment or any discussion boards?*

Like a two star Yelp review, this email embodies my vexation with teaching online. My perception of being extremely "present" to my students is not perceived by some of them. I feel that I must be leaving out some of my spice when delivering information online because the students cannot see how passionate I am about their success and how much I value their work.

A Chef's Journey to Extend the Ultimate Dine-In Experience

Meredith Kier, ***College of William and Mary***

Venture

I CONTINUE STRIVING TO PROVIDE THE ULTIMATE DINE-IN EXPERIENCE ONLINE as I take on a new venture of designing an online community for STEM educators, middle school math and science teachers, and engineers in government and industries to work together in an effort to teach middle school students how to use engineering design processes to solve real-world engineering problems. The implementation of this project will occur with an urban school district of teachers and students who are predominately African American. My experiences with teachers in these schools and with students who attended these schools reinforces how important personal connections are to sustainable change.

My colleagues and I at Howard University (the chefs) are working through the construction of this online community, building it slowly, and eagerly searching for better understandings of what structures are needed to make our participants feel like they are dining-in and that the chefs are always available to them to meet their needs. The following activities will take place within this project:

1) STEM educators will provide engineers synchronous and asynchronous professional development (PD) to enhance their abilities to Skype with middle school students and explain their careers and career practices.
2) Teachers will collaborate online with STEM educators and engineers during synchronous online meetings. During these sessions, small group chat rooms will be formed among teachers of the same grade and subject, a STEM educator, and an engineer. Together they will discuss how to best integrate design challenges into the formal curriculum, and discuss real-world connections between the practices used to design solutions, practices outlined in the Next Generation Science Standards (NGSS) and daily practices of the engineer.
3) Students will post their designs online, reflect on their design and implementation, and discuss with other students how designs may be modified.
4) Social media platforms will be established within and between all members of the community allowing a space to discuss ideas further, ask questions, and share resources.

With my vexation at heart, I believe that the implementation of these activities will be no easy feat, especially because I have relocated to a new institution. Arroyo (2014) identifies key elements to take into consideration when delivering online instruction at an HBCU; I believe that these elements are relevant to this project. These elements include: 1) assessing the environment and culture that instruction is to identify the costs of delivering instruction online; 2) developing a detailed pedagogical plan that is mindful of the collective culture and maintaining a small online community so that students can build relationships with their classmates and the professor; 3) developing a set of benchmarks to continually assess the quality of online communication and exchanges, and, 4) hiring instructors to deliver instruction who understand the potential costs of online teaching and learning within the school's context. I am most perplexed by developing the "pedagogical plan" of the project that is very mindful of schools' culture. A few of the many questions that I seek answers to are: As the head chef, how do I convey my personal connectedness to my customers and my food? What strategies would you suggest to ensure maximum social presence (Swan & Shih, 2005) between members of the online community? How do you encourage participation in asynchronous discussion boards? Are there ways that the project team/STEM educators need to model asynchronous discussions to motivate others to contribute their thoughts and questions? Which venues are best suited for these different social interactions to take place? I hope to glean more insight into how to package my flavors and deliver this experience when it comes to fruition in the near future.

What is the Role of Science Education in the Effort to End Mass Incarceration?

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

Vexation

MY VEXATION CONCERNS A TOPIC THAT I HAVE PONDERED FOR TWENTY-FIVE YEARS, and in my recent achievement of tenure and promotion, I find myself now motivated to begin a line of inquiry that I have avoided for all of that time. In 1991, in the midst of my teacher preparation program, I volunteered as a mentor to a 7th-grade student whose father was incarcerated, and I began to view prison for the first time as something that happened to fellow human beings–a realization I had never had. At the same time, I was tremendously impressed by an adjunct professor at Trenton State College whose other job was working at Trenton State Prison as a teacher.

His boss was my father.

With the exception for a brief three-year period when we lived in Colorado, my father worked for the state of New Jersey as an accountant. In the early 1980s–during a period of state reorganization–he was transferred to the state prison system to run the finances of various prisons throughout the state. Over time, this encompassed all purchasing done by the prison system, including contracting for inmates' educational services. As a young adult, I started putting the pieces together and decided that my middle-class upbringing had been made possible by the incarceration of men and women. I didn't know how to feel about that, other than to consider the fact that clearly people who were in jail were there for a reason, and that the criminal justice system had operated with due process to put them there. I made my peace with this fact, but still nursed a notion that someday I might contribute to this system from which I benefitted.

Over time I learned about the primacy of property rights over human rights in both historical and contemporary legal battles (Delgado & Stefancic, 2012; Ladson-Billings & Tate, 1995), institutional racism and the legacy of slavery (Ladson-Billings, 2006), and the savage inequalities that continue to exist across schools and communities in the United States (Kozol, 1991). I became a physics and chemistry teacher, and–attuned to these inequities–studied multicultural education both on my own and later in graduate school in order to make school more fair, at least in my little corner of the science wing. One purpose I strove for in my work was to help sand off the rough edges of injustice as best I could, even while advocating for transformations in larger systems (such as in teacher education). And then I learned about mass incarceration.

Described as a "New Jim Crow" by Michele Alexander (2010) resulting from the operation of a racial caste system in the U.S., mass incarceration can be described by the crisis of an unprecedented increase in the US prison population between 1972 (200,000; or 161 per 100,0000) and 2009 (1.5 million; or 767 per 100,000); a population overwhelmingly comprised of poor men of color (Travis, Western, & Redburn, 2014). Especially when it seems like every week another unarmed black man is killed by police, I can no longer maintain my earlier assumptions about the fairness of the system that has placed so many people in jail. Now that I possess the relative privilege of a position in the academy, I am wondering what exactly I am positioned to do about it.

I have looked into education programs in prisons–many of which withered away after Pell Grants for prisoners were forbidden by a 1994 Omnibus bill signed by Bill Clinton (Tewksbury, Erickson, & Taylor, 2000)–and most of them are small scale operations run through the state in partnerships with liberal arts institutions and community colleges. This past semester I found myself in the uncomfortable position of informing a promising college student of color with a decade-old criminal record that his background precluded him from obtaining a teacher credential under current state licensing requirements. His story is likely one of many barriers to post-institutionalization education and employment, as well as wider civic engagment.

My vexation is that this is not my field at all: I work at the intersection of science education, teacher education, and multicultural education. Yet I also know that being a steward of education in the public interest is at the heart of what I do. Whether I am working to interrupt the school-to-prison pipeline (Meiners, 2011), working somehow within prisons in a rehabilitative sense, or aiding in the larger effort to "decarcerate" our society and easing prisoners' transition back into society, I have a strong urge to play a role in this larger social project for justice. I wonder further what role science education might play.

What is the Role of Science Education in the Effort to End Mass Incarceration?

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

Venture

CERTAINLY, LEARNING SCIENCE IS AN INTEGRAL PART OF ANY LIBERAL ARTS EDUCATION, BUT FIGURING OUT WHAT MY ROLE OUGHT TO BE IS VEXING. Figuring out what role science education might play in the effort to end mass incarceration is even more so.

Yet the broader outlines of a venture are coming into focus for me. In the state of New Jersey, there is a program called NJ-STEP (Scholarship and Transformative Education in Prisons) with a statewide enrollment of about 700 inmates in state prisons. A consortium of state higher education institutions participate in this program—releasing faculty with on-load credit to teach courses in prisons. Sadly, my institution does not participate in this program. Further, even if my institution did participate, I would likely be ineligible to teach science in NJ-STEP because I am not a faculty member in a science department.

I do not particularly see this as a barrier, and I think that any effort to make such work a part of my academic load would be premature. My venture, somewhat humbly, is just to volunteer in the program (as a state-certified high school science teacher) just to get a sense of how education really works in a prison, and what the actually opportunities are, given the political realities. Yet I also feel it would be good to use the opportunity of this conference to help flesh out some of the theoretical and pragmatic aspects of this venture before I move forward.

Here are some questions for group as I take the first tentative steps in the direction of this venture:

1. In the broadest sense, is it productive to begin an inquiry into what role science education might play in the effort not just to ameliorate but end mass incarceration?
2. It seems there are three distinct places of action for engaging in this issue: a) the school-to-prison pipeline, b) within prisons themselves, and c) post-prison & rehabilitation/re-entry programs. Where ought I focus my efforts?
3. There are public fears around science education and incarceration (e.g. teaching chemistry to people with drug convictions), how do we as a community mitigate these? More specifically, how does the substance of science education, not to mention pedagogy, need to be shaped to work in this context.
4. Perhaps most importantly, what sort of things should I look for as I begin volunteering as an insider? How might work done with other vulnerable populations in science education inform the direction of this project?

My hope is that this venture will lead to greater insights that will help guide the development a much larger project—sourced out of the academy and my other work in science education—that will be a part of the larger "decarceration" movement, so I am thinking about engagement in terms of where is it most effective to act.

Building Statistical Narratives: The Foie Gras of Science Education?

Karen Lionberger, ***University of Georgia***

Vexation

RECENTLY, I WAS ATTENDING A PROFESSIONAL EVENT WHERE SEVERAL FIRST-GENERATION COLLEGE STUDENTS ("first-gens" as they refer to themselves) spoke about their journey through the K-12 educational system and discussed what factors proved synergistic in propelling them to be the first in their family to enroll in college. I was fully expecting to hear some amplified, emotional stories about the passionate, dedicated teacher or administrator who would not give up on them – you know, evoking images in my mind of the likes of Michelle Pfeiffer in *Dangerous Minds* or Morgan Freeman in *Lean on Me*. While that type of motivator was certainly a part of the stories shared that day, the more compelling account came from one student who cooked up a new picture of motivation for us with the main ingredients being the myriad of public-facing statistics that tend to look more like a recipe for failure rather than success. Even as a young student in high school he was keenly aware of all of the "numbers" that were being used to tell a story about first-gens…problem was…it wasn't *his* story.

> *"… and I feel like all of these numbers, tables and graphs were creating a narrative for me that wasn't my own. Included in this narrative is the fact that on average first-gens are much less likely to obtain a degree from a four-year institution when compared with their peers. But you know what is not average … me. You know what is hard to graph … my resilience."*

Sharing the best paraphrasing my mind can conjure of this young, passionate student's source for motivation is an attempt to elicit from you the same guilt I felt upon hearing his story. This student's words have continued to boil over in my mind for several weeks now. Possibly this is because I've realized that I am, in fact, frequently guilty of building a dialogue with policymakers or school-level decision makers centered solely on characterizing STEM students with simplistic statistical narratives. Why? Because it breeds buy-in to education research. It's an easy foothold into trying to grease the ever-illusive pipeline between research and policy. Why is there such deeply rooted dependence and reliance on statistical findings by policymakers and school leadership? I have increasingly noticed this phenomenon over the course of the last year through my conversations with state and district leaders attempting to use statistical data as a narrative of causation for the complex barriers associated with supporting and engaging students in challenging STEM coursework. What further exacerbates this issue is that the data used are typically statistical snapshots, distilled from larger, richer analyses of data, unfortunately taken and used in isolation.

To clarify, I'm not insinuating that policymakers or school-level administrators are willing vectors in the reliance on these piecemeal statistical narratives to characterize STEM students, teachers, or classrooms. I'm sure we all realize the pressures of school accountability in a litigious, watchdog era where standardized testing is king and becomes a catalyst in making these quantified narratives quite possibly the foie gras of science education. To some, utilizing this type of data to inform policy is a luxurious, tantalizing meal that should be consumed whenever possible. Yet others, like myself, would like to raise the flag of controversy of the force-feeding of fatty statistics alone in order to characterize these students rather than also relying on data of more nutritious, qualitative substance.

If we continue to allow the addiction of quantitative representations as means to solely characterize and inform policy about supporting STEM education, we will be left with uninspiring and benign reform efforts in the classroom. This will be particularly harmful to the traditionally underrepresented students in STEM, such as first-gens, ELLs, minorities and females. Bakan (1966), as he stated almost 50 years ago, expresses the spirit of my vexation when he says, "When we reach a point where our statistical procedures are substitutes instead of aids to thought, and we are led to absurdities, then we must return to the common sense basis" (p. 436).

Venture

MY ENDEAVOR IS TO START A DIALOGUE WITH POLICY-MAKERS THAT PRIORITIZES (UN)COMMON SENSE – given that currently common sense is leading to the flashing of tables and graphs on PowerPoint slides in order to make educators feel as though they are making a more objective, empirical decision about how best to support STEM education, especially in light of the recent efforts of NGSS. Realizing that simplistic statistical representations of these students possibly persist because they offer a more digestible, user-friendly way to engage with education research, and therefore absolve decision-makers from having to make "value judgments", how do I even begin this conversation?

Building Statistical Narratives: The Foie Gras of Science Education?

Karen Lionberger, ***University of Georgia***

My need for innovative guidance from Crossroad collaborators about generating a new conversation will be timely, as I will be engaging in these discussions with districts that are partnering with us, my colleagues and me, on the implementation of new high school math and science educative curriculum materials over the next two to three academic years. As participants in this pilot, teachers will implement classroom-based instructional modules and accompanying performance assessments as well as engage in over 50 hours of professional learning experiences with us.

First and foremost, I'm concerned that trying to change the typical conversation with district leaders will immediately be perceived as easy to dismiss if it is not sensitive to the federal and state accountability measures they are held to each year. Also, even if buy-in is gained for developing a more robust picture of what counts when assessing student proficiency and teacher effectiveness in STEM disciplines through the inclusion of qualitative, contextualized data, it will simply be seen as a "nice to have" and will always take a back seat to statistical narratives of students.

I'll share a few notions I'm currently entertaining not because I fervently hold to them but rather in hopes they serve our greater purpose of generative dialogue:

- **Empowering teachers as researchers** – For large-scale curriculum implementation programs, such as those from textbook publishers, the tantalizing conversation to district leaders promises efficacy research on student learning outcomes in connection with their materials. This normally results in top-down, internal and external accountability tools that continue to disenfranchise teachers and fuels their reform fatigue. Instead, we could consider design-based implementation research that values teachers as the agents of change in the classroom by focusing on co-designing, analyzing, and modifying our pilot curriculum materials and professional learning opportunities (Penuel, et al., 2011). This type of research would allow prioritizing a bottom-up flow of defining effectiveness via the robust, qualitative accounts of teachers' reflections on *enacting* the pilot curriculum components – not just simply *implementing* them. These stand in stark contrast to efficacy studies that commonly rely only on decontextualized statistical evidence of student improvement measured by benchmark assessments or end-of-course exams.
- **Explicitly attending to noncognitive factors** – A new conversation about the interconnected nature between noncognitive factors and students' academic success may provide a viable landscape for pushing away from sole attention being placed on reducing students to a quantified result of a high-stakes, standardized test score. For example, emphasis could be placed on teachers' reflections on explicitly attending to facets of building academic mindsets and student self-efficacy. This type of contextualized research into noncognitive factors is critically needed as some research points to the possibility of narrowing the achievement gap for students who are underrepresented in STEM disciplines by explicitly attending to these malleable characteristics of students (Farrington, 2012).

Keep in mind I'm not suggesting or implying that the use of analyses from quantitative studies be eliminated from the conversation or that they don't have their own proper place in science education research. I merely venture to move it to the top of the proverbial food pyramid, much like where foie gras should be placed, whereby the suggested frequency of consumption/use as the sole nutrient in which to inform science education policy is… "sparingly."

Reverse Engineering an Educational Base

Heather Mars, ***Independent Educator***

Vexation

THERE ARE CAREERS THAT WE CULTIVATE AND TRAIN FOR, AND THEN THERE ARE THE CAREERS THAT BEFALL US. It starts with small adaptations, minute spontaneous actions followed by intuitive counters, and then one morning you realize that you are entrenched in work that is entirely transformed. The fault in these spontaneous careers is that without a firm educational framework, the ability to evolve is limited. There is a purpose to training and formal education; it gives structure, a commonality of language with others in the field, a community to draw from, a basis for research, and a potential for a greater depth, beyond personal passion.

This is where I find myself. I stand at the threshold of a career for which I have no specific training. All of my current work is based on personal research, instinct, informal experimentation, and trial and error. I want to reverse engineer myself an educational base for what I already do, so I can grow and expand.

I tutor math. That sounds simple, trite, boring. Technically, "I tutor math", but in action it is so much more. Most of my students have significant math learning disabilities, both clinically diagnosed and not. These are children whose brains struggle to hold numbers, patterns, or abstract concepts. The information slides over them, like oil on teflon. I have students who can work through a basic math concept for twenty minutes, declare themselves proficient, and then the following day, claim to have never seen the problem before. A concept can be learned in one form, but my students struggle with being able to translate that skill to another related concept. Nothing is a given, nor obvious. This is slow work, not to be rushed. It is repetitious, individualized work; what one student relates to, another finds unfathomable. When I say, "I tutor math" what I mean is that I attempt to translate mathematics from a threatening mystery to a personalized, accessible skill that they can use with confidence, if not joy.

I am entirely self taught in this field. My educational background is in physics (BS in Physics, University of Oregon, 1995). I've had a variety of non-physics jobs since then. Most recently, I've done extensive work (both paid and volunteer) at the elementary school level as an art teacher. I stumbled into math tutoring when a friend's daughter was struggling with 4th grade math. She had been diagnosed with dyscalculia and a severe pattern deficiency, and had been given a doctor's recommendation to cease taking grade level math. Math was a thing of anxiety attacks and hatred. Using coping methods I had developed for my own dyslexia as a template, I parsed together a strategy to work through her learning disabilities. We are now finishing our fifth year working together. What began as tentative forays into basic concepts, has grown into complex workings of geometry and algebra. Academically, she now keeps pace with the top of her math class, but more significantly, her thought process has evolved. Nothing mathematical comes easily or quickly for her, but she is determined to craft an understanding that works with her brain; she does not fear math, and math will not limit what she pursues.

My students view the world the world differently. Their perspectives are unique. Another student, a fifth grade boy, brought me his geometry test. There was a sketch of a hexagon on the test, and he had been asked to give three distinct facts about the shape. He said it had six faces, was a cube, and a quadrilateral. His teacher had marked the first response correct, and the next two wrong. I was puzzled, because geometry is usually a strong subject for him. Looking at the hexagon, I saw he had sketched in additional lines, and then erased them. When questioned, he told me that he had tried to draw in the missing lines, but he couldn't make the perspective work. In his mind, he saw a three dimensional cube, not a two dimensional hexagon. When he realized the disconnect between his perception and his teacher's purpose, he wanted to know why his teacher hadn't specified that the shape was only in two dimensions.

When my students become frustrated or self conscious in their learning, they have my complete empathy. I know what it is to be wrong in a public arena. I have my own experiences with seeing the world uniquely, as documented in A Private Universe. The creative orbit I created in 1987 is clearly wrong, yet it is its extremity that created an impactful learning experience. The experience of being "Heather" highlights my goals in tutoring. I want, not just to teach the correct method of the math at hand, but I want to help the student understand how their thinking can relate to the external world.

What began as one student, has grown by word of mouth. I currently have 9 students, who range in grade level from 3rd to 10th grade, but most of my work is centered on middle school (6-8 grade) level.

In the past five years, my attention has been caught by the similarities and disparities among my students. I am constantly struck by the "Why?" Why does one student understand a concept this way, and another not? What is happening in their brains as we build

connections? I can witness new connections being made, but how do I quantify it? How can I best optimize their learning, and my work, to assist them? How do I best track their learning?

For example, I have a male student who struggled with long division. We tried an array of methods for understanding the concept of division, as well as performing long division. Over a period of 6 weeks, we would meet once a week and work on a specific method. I'd rotate the methods (grouping, clusters, menus, traditional algorithms, etc.), trying to find one that would work for him. Each week, I'd set up a problem, and he'd say, "I have no idea how to do that." Each week, I'd ask him what he remembered, so we could build on that. Then, one week, he came in and said, "I know how to do this. My teacher showed me how." He sat down and flawlessly executed a long division technique. "Why didn't you show me the menu method?" he asked. He had no conscious memory of having been shown that method multiple times before. On this particular day, it "clicked." And, months later, he still owns this understanding.

Venture

I WANT TO KNOW THE "WHY." I SUSPECT THAT HIS SHORT-TERM MEMORY DOESN'T "HOLD" MATH. My theory is that by repeating the information over and over again, with slight variations, we bypassed his short-term memory and reached his long-term memory. This ability of the brain to gain long term memory imprints, without short-term memories, has been seen in adults with brain injuries or disease. I think this is what's happening with some of my students, but I want to know. I want to have the scientific base to really understand what is occurring within the brain. And, if my understanding is erroneous, I want to know that, too. While learning additional techniques for teaching is always beneficial, I want more than just new tools in a metaphorical tool belt. It's just not enough to have a technique that works, I want to know what about it is being successful. I want background science in whatever form I can find it, whether it be biological or behavioral.

My current, personalized method of work begins with trying to understand how a student sees numbers. (Is multiplication a series of additions, counting by groups, a memorized series, or a coded system of prompts?) I present concepts in multiple formats, until we find a way of thinking that works for their particular way of conceptualizing. I then use their strengths to build a network of inter-related concepts that bridge what their teacher is presenting to their personal way of understanding. I constantly ask them to focus on what they know, before they are distracted by all of the things they don't understand. "What do you know, and where can we go?" By linking the concepts together, I find that students can rebuild knowledge they might momentarily misplace. We also talk about anxiety and the emotional distress that comes from not grasping as quickly as their classmates. "Give yourself permission to not understand in the moment. We will get there. Be kind to yourself."

I am passionate about what I do. I find it complex, challenging, invigorating, and beautiful. But I have reached the point where I need to have more knowledge to continue to expand what I do. I am no longer content to MacGyver my way through tutoring. My students deserve a science based approach, not just what I've cobbled together with good intentions. Additionally, I am language deficient in relating what I encounter. I witness learning, but I do not have the tools or methodology to record what I see.

This is my Vexation: I want to better understand what I do with my students so I can increase my ability to help them. I want science behind my ideas, and knowledge behind my assumptions. I want to make my pursuit a grounded career. I want to be able to share my findings, as well as ask for assistance when I am stalled. Eventually, I would like to diverge into research to capture more purely what I think I am seeing.

This is my Venture: How do I reverse engineer an education to match what I know I want to do?

Where do I start, given that I know where I want to end?

I don't want to teach math in a classroom, but I need to understand curriculum. I think I need to understand the brain. Do I begin in biology? In brain research? MRI's? In metacognition? Learning disabilities? Psychology? In a teaching or a special education program? I am open to all possible avenues of instruction.

Developing Pedagogical Chefs: Teacher Education as Creativity and Human Centered Design

Scott McDonald, ***The Pennsylvania State University***

Vexation

CHEFS PREPARE THEIR *MISE EN PLACE*; TEACHERS HAVE THEIR LESSON PLANS. Maybe teachers don't typically tattoo themselves with the implements of their craft, but our students leave indelible marks on us defining who we are. At their best, cooking and teaching are both conversations. Teaching and cooking both require a delicate balance between detailed preparation and responsive improvisation. As teacher educators we are like instructors at the Culinary Institute of America: helping our students take into account the daily variation in ingredients/students to create consistent, yet unique and powerful experiences. When done well, both cooking and teaching leave participants so focused on the experience the chef/teacher becomes invisible or taken for granted.

The invisibility of great teaching is at the core of my vexation, which focuses on the tension between preparation and improvisation. It is a problem not to be solved, but to engage with, in an effort to improve. My vexation is a recurring annual event, as it is always part of the redesign of my science teaching methods course. I have been teaching this course, in one form or another, for fifteen years. I always seek to improve it, but this year I am choosing to engage with a different aspect of the problem, or at least engage with it differently. I want to frame preservice teacher learning as a problem of vision, in particular a problem of professional vision (Goodwin, 1994). Professional vision is the theoretical framework guiding both my teaching and research. Goodwin focuses me on learning to teach as a process of acculturation. He reminds me to think in terms of the culture when designing pedagogical experiences for my teacher candidates and also the cultural way I want my teacher candidates to think about teaching. This year as I iterate my class, I am choosing to focus on the professional tension between preparation and improvisation.

This leads to another parallel between cooking and teaching – there are a lot of cooks in the world, but few chefs. Cooks can prepare exceptional meals; they can be masters of their craft, but at least in the strict culinary definition, they are not chefs. They are craftsmen/women, but not innovators/artists/designers. While I know most of the teacher candidates I teach will be pedagogical cooks, My goal is to create an experience that allows for the possibility of one of my students becoming the Ferran Adrià[1] of science teachers. What transforms human beings from followers of recipes to culinary adventurers? How do I provide experiences for my teacher candidates to help them see the world not as a place to emulate, but as a place to innovate and transform? What would happen at the El Bulli Lab for teaching? How can I design my course/program be such a place?

Teacher education has recently focused on defining the core practices as a way to guide the design of programs. The conversation is both in disciplinary communities (e.g. science education) and in the general teacher education community. What are the (practices) ingredients for an excellent teacher education experience for future science teachers? Grossman and McDonald (2008) identified three ways of working with teaching practices to support professional teacher education: representation, decomposition, and approximation. Rehearsals are one example of an approximation of teaching practice characterized in detail (Lampert, et al., 2013). These scholars have helped me think about teacher education, but they seem to target the creation of cooks, not chefs. I want to think about the difference between technically excellent science teachers and adaptive experts, who feel that to teach is to create and to improvise, not execute. We are living in/through a national conversation that increasingly deprofessionalizes teachers and conceptualizes teaching as a technical skill requiring little formal preparation. I want to embrace and emphasize teaching as creative design work and help my teacher candidates see teachers as creative professionals.

Venture

SO, IF I AM GOING TO CREATE CHEFS AND NOT COOKS, if I am going to define teaching in terms of creative design work, what can I do to take that idea seriously? My thought is to draw on the experiences of practitioners in creativity and design. In addition, beyond thinking about what new practices I want to bring into my course, I also want to articulate the value of these new practices. To this end I want to iterate my course in terms of a set of design principles for (science) teacher education. I am working this summer on a clearly articulated notion of a design principle in general, and I will ultimately use the definition to guide how I talk about designing teacher education. In the meantime, the initial thoughts guiding my design are:

[1] Famed Catalan chef owner of El Bulli and the El Bulli Lab in Barcelona (http://www.elbulli.com/)

Scott McDonald, ***The Pennsylvania State University***

Designers must have empathy for the community they design for. I will explicitly talk with my teacher candidates about incorporating design into the way they think about teaching. This past spring semester, I taught a course using IDEO's notions of human centered design (HCD)2. The first phase of their design process focuses on the concept of "hear." This is IDEO's version of the research phase of the design process. One piece of this process that struck me was IDEO's emphasis on empathy. I realized one of the persistent issues my teacher candidates encounter is they don't really understand the life of a middle/high school student, in particular a student not like they were at that age. My experience is they often come back from their early field experiences with significant deficit models for students – seeing them as unmotivated and lazy. Given that, I would like to think about ways I can help my teacher candidates develop empathy for the students they teach, and as an result better understand the actual community for which they are designing their educational experiences. This phase primarily involves understanding the people for whom you are designing. **What kind of structures/activities do we need to have in teacher education to help teacher candidates develop empathy for the students they teach and the communities they teach in?**

Designing pedagogical environments/experiences requires prototyping. Prototyping is another common design practice included as part of IDEO's HCD, but it echoes an idea I learned from the writer Anne Lamott (1994) – the idea of a "shitty first draft." While teacher educators recognize teaching is a difficult and complex activity, we have not explicitly taken up the role of failure in learning to teach. The way you learn how to do any complex task, including creating something, is to try it, even an approximation of it, have it fail, and learn from that failure. Some of teacher candidates' failure could be done in teacher education contexts, through approximations of practice such as peer teaching; however, we need to build this capacity in our students, so that it becomes a common part of their practice in school. Also, as an extension of this, we need to think about how to shorten the cycle of iteration for prototyping in education. If everything occurs on an annual cycle, there is tremendous inertia in the system. It is hard to engage in intelligent fast failure (an engineering term) without the fast. **What kind of structures/activities do we need to have in teacher education to help teacher candidates create professional structures to learn from failure, especially when they are in their induction years and beyond?**

Designing pedagogical environments/experiences is a creative activity. My final design principle is that teacher candidates need to learn to see their role as a creative activity. I have always been wary of the notion of teaching creativity; however, Lynda Barry recently released *Syllabus: Notes from an Accidental Professor* (2015), which is a collection of writing exercises and creativity advice from a course she teaches at the University of Wisconsin, Madison. My experience with this book, and the openness and honest with which she approaches what it means to be creative, has led me to think we need to specifically engage our teacher candidates in creative activities as a way for them to expand their notions of who they are as teachers. This seems especially pertinent in science education, where the disciplinary field of science is also grappling with how to be seen as a creative endeavor. Expert teachers (and teacher educators) recognize creativity is part of both the long term planning and in the moment improvisation of teaching. **What kind of structures/activities do we need to have in teacher education to help teacher candidates reconceptualize themselves as creative professionals?**

[2] IDEO is an international design firm started in Palo Alto, CA co-founded by Tom and David Kelly. IDEO and the Kellys have published a number of books focused on design and design thinking (http://www.ideo.com/).

Igniting Passionate Science Education: Science Teachers Identifying as Scientists

Peggy Mansfield McNeal, ***Western Michigan University***

Vexation

THE FUTURE OF SCIENCE IS IN OUR CLASSROOMS. The students that fill the seats in our lecture halls, labs and public schools are the seeds of future innovation and scientific development. What are we doing to nurture these seeds? How do we ensure that our students will think critically, yet ingeniously? How do we prepare them with the level of scientific knowledge necessary to meet the skill level demanded by the scientific enterprise, current technology, and global problems? Most importantly, how do we interest students and turn them toward science, instead of away from it?

Through my observations and experiences with science teachers and science teacher programs, I have met some phenomenal teachers. We all personally recall these teachers from our own science education. They are the ones that sparked our interest in science. Perhaps they gave us the chance to participate in exciting labs. Maybe they took us on stimulating field trips. Likely, they greeted us each day with a level of enthusiasm that created an eagerness for learning. These experiences fueled my passion for science. They emanated from devoted teachers who purposefully designed lessons that involved students in the scientific process. Yet, many (most?) of the students who enter my science classroom on the first day of school tell me that they do not like science or that they are not good at it. This vexes me.

I know a high school earth science teacher who spends summers with students on a grand camping tour of the country's prominent national parks, making geologic observations and collecting data along the way. Another teacher holds mock U.N. Climate Summit meetings with her students as IPCC representatives. Many science teachers participate in research through professional development opportunities and share these experiences with students. I know of a classroom where students Skype with an Antarctic researcher on a regular basis. I met a teacher who has his students wade into the campus retention pond with homemade gravity corers to collect sediment samples. I have spoken with a teacher that involves her students in cloud observations and provides ground truthing for weather research satellites. These teachers inspire me and push me to become a better teacher myself.

As a veteran middle school science teacher, however, I know that, sadly, these teachers do not represent the norm. For this, I do not place blame. Science teachers are laden with additional responsibilities outside of strictly teaching science. They feel burdened with requirements to cover an exhaustive list of science standards and by the responsibility for student performance on standardized science tests. They have numerous demands on their time and finding occasions to develop new curricula or connect with outside resources is difficult.

Unfortunately, I also know science teachers who are not excited by science and do not exhibit a love of learning. We all remember these teachers as well. We completed numerous worksheets in their classes and perhaps watched many movies. The teachers delivered the knowledge without giving opportunity for questioning and wonder. These teachers may have other motivations for participating in the profession. Perhaps they lack science training. However, I am concerned for students with science teachers who do not model active learning themselves. This vexes me.

Michael Berkman and Eric Plutzer published an article in March 2015 in The Annals of the American Academy of Political and Social Science titled, ***Enablers of Doubt: How Future Teachers Learn to Negotiate the Evolution Wars in Their Classrooms***. The article builds on previous research that showed how biology teachers contribute to opinion on evolution. Having discovered that many teachers legitimize creationist perspectives (even those who do not hold these beliefs), they set out to investigate the source of the problem. What they exposed in the course of their focus group discussions with pre-service biology teachers is extremely disconcerting.

The article reveals that among the pre-service biology teachers, "…very few showed a passion for science more generally and scientific research in particular. Indeed, most showed little interest in popular science" (Berkman & Plutzer, 2015, p. 261). The authors asked the pre-service biology teachers how they keep abreast of contemporary science and typically, the pre-service teachers disclosed that they do not partake in opportunities that nurture an interest in science. Even more alarming, the pre-service biology teachers showed no indication that they would be "warriors" for evolution in the classroom. They did not relate to movements or controversy in a way that elicited a forthright treatment of evolution. Instead, they "anticipate treading lightly on evolution as a means of both preempting potential conflict and dealing with controversy that arises" (Berkman & Plutzer, 2015, p. 264). Similarly, they did not show interest in becoming involved in scientific research.

As a graduate student instructor and researcher in science education, these findings perplexed me and I wondered how they might apply to climate change education, a personal area of interest. I had already designed a study to examine the practices of

Peggy Mansfield McNeal, ***Western Michigan University***

teachers teaching climate change in anticipation of the implementation of the Next Generation Science Standards. I planned focus groups to talk to teachers who have already begun to teach climate change and find out what was working for them. However, with this new information, I also wondered what motivates teachers to teach this controversial topic and what sets them apart. With this in mind, I slightly modified my questions to see what might emerge from the focus group conversations.

The teachers in my study self selected from a recruiting email, so this was not a representative group of teachers. I specifically targeted teachers who were already teaching climate change voluntarily. As a result, I collected a group of outstanding teachers who were highly passionate about science and advocates for climate change action. Through the guided focus group discussions, a strong theme emerged. These teachers identify as scientists as strongly as educators. These teachers work hard to be climate change experts by reading literature and seeking new knowledge. They each maintain relationships with research scientists and a few had participated in research with scientists. They engage in the scientific process and include their students by involving them in authentic, local data collection. Their students analyze their own data and draw conclusions. In one case, student research was presented at a scientific conference. These are behaviors of active, researching scientists and indicate that these teachers see themselves as scientists. Indeed, one participant even said, "I'm a scientist first." This characteristic, identification as a scientist, is what sets these teachers apart.

I asked these teachers if there were other teachers at their schools teaching climate change and they unanimously replied "no." They cited lack of collaboration and required teaching standards as barriers to this type of science education. It appears that these teachers are outliers in an otherwise noncommittal environment. This vexes me.

What can be done to ignite more passion in science teachers so that they pass a passion for relevant science on to their students? How can science teachers develop as scientists, both personally and with their students? Is it possible to develop this disposition in all teachers, present and future, instead of it being characteristic of only a few? Especially in an era of increasing public science skepticism, the future of the scientific enterprise depends on having invested, passionate scientists in the classroom.

Venture

I DARE TO DREAM BIG, HOWEVER, MY VENTURE STARTS WITH THOSE WHOM I CAN MOST IMMEDIATELY IMPACT: my own students in an undergraduate atmospheric course for pre-service elementary school teachers. Although programs exist that join scientists and practicing teachers (with varying degrees of impact), I have not encountered opportunities that encourage pre-service teachers to conduct research as practicing scientists. Nevertheless, the pre-service elementary school teachers that I teach will soon be faced with NGSS-type standards that require them to teach the practices of scientists, specifically, to investigate and build theories about the natural world. How equipped will my students be to do this without personally engaging in scientific research? How passionately will they teach science without first hand experience collecting exciting, relevant data related to meaningful investigations? Their exposure to research in my classroom is rich, yet still limited. It is not the same as working in the field with a practicing scientist. Taking a science course does not usually lead one to identify as a scientist.

I would like to create opportunities for my students to participate in local weather and climate data collection as part of an REU or internship type experience that is typically reserved for their science major peers. Potential collaborators include meteorologists and climatologists at the Michigan State Climatology Office and the local National Weather Stations. Pre-service elementary education teachers could also assist with research in the geography department on climate variability and climate change. The goal is to design a program that involves them in local climate and weather research so that they have a background from which to create relevant science pedagogy that feel connected to. Although my initial ideas revolve around my own course in atmospheric science, I envision that if successful, the project could extend to other science disciplines and colleges.

Many questions remain as to how to begin. Do programs exist that I can use as models for this idea? How can I effectively liaison with local scientists such as those at the state climate office and national weather service? How do I ensure quality science experiences that inspire passionate science teaching? What are potential funding sources? Most importantly, how do I convince all involved (including my students), that there is as much value in this type of experience as other pre-service teacher opportunities (such as working in a school)?

A Researcher Reflects on Research-Practice Partnerships

Savitha Moorthy, *SRI*

Vexation

My first job, after high school, was at a popular restaurant as a line cook. Although the menu included a number of crowd-pleasing customer favorites, the chefs wanted to keep things interesting. So, every quarter, they revised the menu, adding seasonal specials and replacing slow moving dishes with more lively candidates. New recipes, developed by the chefs, debuted on the menu as "specials." This was the first opportunity to see how the dish would fare under the circumstances of a real world restaurant, and the preparation cooks would need. After all, no matter how delectable a dish, it was unlikely to be popular if it took too long to prepare or arrived at the table cold or burned. As the chefs watched the cooks' tackle the specials, they tasted, took notes, and asked for feedback, and adjusted the recipe based on what they observed and what we said. Dishes that survived the trial were promoted on to the regular menu; those that didn't, bit the dust.

The metaphor isn't a perfect fit, but there are some ways in which the trajectory of an education reform is like that of a new menu item. In the same way that creating recipes is in the chef's wheelhouse, designing an educational program is the responsibility of expert researchers with specialized training. Like line cooks experimenting with daily specials, education practitioners are involved in testing the program, providing valuable information about its usability, and, ultimately, contributing to its improvement. However, it's rare for line cooks to stand beside the chef, offering ideas about how to adjust the recipe to make the dish more practical for their restaurant. Similarly, it's uncommon for front line education workers to partner with researchers, adding practical wisdom to research expertise, to collaboratively design educational programs that work reliably in their schools and classrooms. In both cases, implementation comes at the end of the design process.

The times, however, they are a' changing. In the current landscape of education research, relevance to practice is gaining increasing recognition as an important criterion for rigor. Not only are new models of research challenging how we've traditionally pursued questions of education improvement, but they're also offering viable alternatives. One example is the research-practice partnership, aimed at promoting a "reciprocal 'practice to research' pathway" (Easton, 2013, p. 18). Departing from the norms of the more 'scientific' traditions, research practice partnerships are inviting practitioners into the test kitchen, encouraging them to take a more active role in the design and use of research that addresses their questions and informs their work. Here, the strategies, know-how, contexts, and concerns of practitioners guide the research, informing and influencing the questions, methods, tools, and perspectives of the researchers. Rather than the culmination of the design process, implementation is the starting point.

I'm compelled by research practice partnerships, and the move they advocate–away from "researcher-driven studies of uncertain relevance to practitioners". So much so, I have embraced this model in two research projects, both focusing on the science education of Dual Language Learners. The practitioners I work with often tell me that our research projects are unlike others they have worked on, that they feel valued and like they're making a meaningful contribution. The work is hard, humbling, and more satisfying than anything I've done before. Here would be a wonderful place to write more. I am confident it is hard and humbling – but you indicate that your satisfaction outweighs the burdens. How so? And maybe give us a little example?!

Reflecting on these projects, though, brings up a number of concerns. First, researchers and practitioners operate in cultural contexts that are governed by different workplace norms, different time and productivity pressures, and different criteria for evaluating success. For example, researchers have the luxury of devoting significant amounts of time to research–and we're expected to–while practitioners have other jobs for which they are accountable. The bottom-up nature of the work we're trying to do is at odds with more top-down models of program adoption and implementation that are more common in the district. As a result, it's sometimes hard to find support from the district for getting our busy practitioner colleagues to the participatory design table. A second concern has to do with coherence. Although the district had adopted new science standards, guidance and documentation about the adoption of the new science standards has lagged behind our projects. It is not always clear to our team how well our work will align to district policy, or the steps we can take to promote closer alignment.

Savitha Moorthy, *SRI*

A third concern relates to the agency and authority that practitioners feel, within the context of our projects. It is undeniable that the research focus and questions emerged through a process of joint negotiation. However, the researchers' 'vexations' formed the starting point for both projects, and the researchers' familiarity with funding opportunities and expertise at crafting competitive research proposals that brought both projects into being. Although practitioners outnumber researchers in both project teams, I can't help worrying that researchers' voices, amplified by their 'expertise', are louder–that we're mistaking participation for partnership, and not able to tell the difference.

Venture

For research-practice partnerships to develop into a robust strategy for educational improvement, a number of key ingredients are necessary.

One ingredient is reflection, particularly critical self-reflection among researchers engaged in this work. The goal of such reflection would be to lay bare researchers' beliefs, values, and assumptions, and how they shape focus of the research and the nature of the partnership. Researchers must also reflect on how the vision of practice to research pathway can be translated into a concrete set of tools, routines, and practices.

Another ingredient is openness. While the focus is on examining and improving educational practice, research practice partnerships are also likely to result in a transformation of research methods and tools, the disposition of the researcher, and the relationship between researchers and practitioners, thereby catalyzing theory development. As such, researchers should be open to allowing the experience of working with practitioners to change the research and the researcher.

A third ingredient is accountability. Researchers must hold themselves accountable for representing the work, as they encounter it in the wild. They must also hold themselves accountable to discussing their experiences on research practice partnerships not in the tidy, resolved manner favored by research journals but in a manner that highlight the uncertain, messy, opportunistic, emergent nature of this work.

A final ingredient is community. Researchers should situate their reflective practices and their accountability mechanisms in a larger learning community, consisting of other researchers and practitioners working together towards similar goals. Without clear examples and concrete strategies to enact, researchers can be left to imagine how the process of constructing and nurturing a partnership unfolded in a particular project, and how they might go about orchestrating such a process of their own. The process of making the reflections and accountability visible and public to other researchers would offer a starting point for us – as an education research community – to consider what it means to seriously take up the question of involving practitioners in research, in authentic and substantive ways.

Conflicted, Angry Teacher Looking for Advice on What's Next

Elizabeth Raynor, ***Manchester (CT) High School***

Should I stay or should I go now?
Should I stay or should I go now?
If I go, there will be trouble
And if I stay it will be double
So come on and let me know

-The Clash, ***Should I Stay or Should I Go?***

Vexation

THE PROCESS FOR WRITING VEXATIONS AND VENTURES HAS ALWAYS BEEN LABORIOUS FOR ME, this year is no different. It's not that I have a hard time vexing, that part is as easy as boiling water, but determining what I need from the collected group of science education thinkers and leaders is more like trying to make a consommé. Clarifying the stock to determine what is truly a vexation and not just professional angst causing significant indigestion is a process that I have not mastered. As I write I am finishing up a sabbatical … All right, maybe not, but a three week forced hiatus to recover from ACL reconstructive surgery that I incidentally needed because I was victim of what I'm referring to as a "ski and run" while advising our last ski club trip. I had been hoping that this time would offer me some distance from the everyday struggles and some clarity about my ideas, goals, and writing. What I've boiled down as I've simmered is that I truly struggle with problems that are bigger than me, bigger than my classroom, bigger that my district, bigger than "exceptional" versus "does not meet expectations" evaluation scores.

Further elaboration on the struggles of my particular position will be forthcoming during my session, I am not sure how to continue in a profession where it seems trust does not exist. Trust between administrators and teachers, trust between colleagues, trust between students and security, trust between the community and the public education system. Since our last gathering in Portland last year, I have continually returned to Erin Furtak's session where she declared herself an "Angry Teacher!" And I think to myself, "Yes! Exactly!" But I am so angry that I don't know what to do about it. And what am I really angry about anyway? I feel compelled to work on the system in a larger way, to impact reform in positive ways, to change things to make the profession better, to continue the important work of making the educational experiences for all students impactful and equitable. Others must be angry too, but how do we use this energy to promote good? How do I take off the grim reaper garb and bedazzle myself in a sparkly super-hero getup? I decided the first step would be to search through previous Crossroads proceedings and see what expertise, similar vexations, and advice I might find because many of the experts that gather within this context to journey together have experienced similar transitions to what I am describing. I value the veterans' words and gathered ideas from their words.

Magnia George vexed about science education reform and the work that goes along with reform work. She says, "And this work is incredibly hard, which may explain why we have an institution of schooling that seems to stymie the systemic development of what Henry Giroux describes as teachers as 'transformative intellectuals' who might actually do the work of science education reform" (2008, p. 38). The system described stifles the ability of teachers to develop themselves as experts and practitioners who can implement reform and systemic change. In my experience, this stifling of intellect is intentionally done by those in positions of "power" within the system. Imagine what would happen if teachers developed a grassroots reform movement. Magnia goes on to write, "I have never understood the notion of a double-edged sword more profoundly until I talked with a teacher who was ready to leave (or was leaving) the classroom because of perceived and oftentimes very real constraints and conflicts he/she had encountered in schools. The reality is the teachers who are best suited for the work of science education reform are the ones we are least likely to retain in the classroom" (2008, p. 38). I have this intense inward struggle about whether to leave the classroom and pursue other ventures in order to be more effective in developing the reform I see necessary. But the reality of the constraints placed on my ability to do good work with students makes it such that I am not sure I can survive in the classroom much longer.

If I can't survive in the classroom within the current system, even if I don't want to leave the classroom, what might academia have to offer? Angela Johnson writes, "I also got onto the academic train, a train with enormous inertia, from which one either is forcefully expelled or exits only at particular stops. I got out at one of those stops, found myself on the tenure track, obligingly got onto another express train, and did what I had to to stay on that train – I said what I needed to say and wrote what I needed to write, and I bit my tongue so often that I'm afraid I amputated parts of it" (2008, p. 42). Angela expresses her desire to find her way back to the social justice work that propelled her into academia to begin with. Jim Kisiel vexed about the challenge of, "defining, or at least attempting to define, the extent to which I am able to (would like to?) participate in multiple communities" (2008, p. 46). He discusses defining identity as being a way defining oneself by looking at the multiple "communities" we participate in and how we reconcile our roles and activities within those communities. He states, "To become an advocate (or activist, if you prefer) requires meaningful participation in different communities of practice – research and practice, classroom and informal setting, knowledge-generating and policy-making" (2009, p. 44). Jim says that a person wishing to fulfill such a role must be proficient in the practices and customs of the communities

Elizabeth Raynor, ***Manchester (CT) High School***

that she/he is working in. How does one, though, maintain an identity as a teacher if she/he has effectively left that community? Does maintaining that identity matter?

So who do I want to be? Francis Broadway writes very eloquently on this topic, screaming from the page, "But I'm a practitioner!" (2009, p. 18-19). He discusses venturing to be a researcher that is a practitioner who is, "a person who teaches science to children or 'kids'" (2009, p. 18). Francis ventures to have his work be that of a practitioner, "instead of the researcher who is a recorder, an interpreter, and a teller of the stories and narratives of others" (2009, p. 19). His sentiments resonate very strongly with me. I too want to be someone who writes about what my colleagues and I do, rather than be one to say "you shall" or "you shalt not." Carla Zembal-Saul vexed about, "finding balance between my commitment to engage with teachers collaboratively on teaching and research ventures and finding mechanisms for communicating research findings in ways that are respectful and meaningful to teachers, teacher educators, and others" (2009, p. 92). She discusses the difficulty in maintaining collaborative relationships and using language that respectfully recognizes those collaborations and teachers. I see this as one of the biggest chasms between the two communities: teachers and researchers. It is a strange thing to be "researched": to have your work (and we know that for most teachers, our work is so much more than just work, it is an expression of our very souls and minds) looked at, critiqued, written about, and discussed. Ultimately we teachers are often left feeling inadequate, what we give and do is not enough, and that we are not trusted and do not trust. Research is clearly very important and necessary to inform practice, to validate reform, to drive improvement. But how does one enter into this world without losing connections and identity within the teaching community? Along with Francis, "I strive to create the research that is who I am rather than what I did" (2009, p. 19).

Venture

WHERE DOES THIS LEAVE ME? WHAT IS MY PLAN FOR IMPACTING FUTURE CHANGE? My venture can take one of many paths, and maybe they do not have to be solely separate from one another.

1. Do I stay in my current role as teacher/teacher-leader and if so, how can I protect my sanity and channel my inner "Angry Teacher" to impact education in a positive way? Can I make "restitution with myself" as Kathy Manning describes, to restore, "faith in my ability to teach, to know the child that I have been presented to learn with, but to do it in a way that still honors my love of the subject of science" (2008, p. 54). How does one go about accomplishing this? Can I impact systemic change from my classroom?
2. Do I have a future in academia? What would a pathway in policy look like? How and where can I be most effective while creating research that remains true to my identity as a teacher? I have been wooing the idea of entering in the realm of PhD level research, but I don't want to leave my students whom I love dearly and who bolster my very life with wonder. Will students of other varieties be able to fill this void? I struggle with the appropriate and most effective way to bring research and systematic policies and structure to meet so that the work of teachers can be realized, supported, and respected by a larger community. Work that I know many fellow Crossroaders take very seriously, but I'm not sure is realized in the segmented system "at large."
3. What other options are there? How can I blend the roles of teacher and reformer? Are there options I haven't considered? I suppose that I am looking for an "in between" role, but have no idea what that would look like or how to have time.

I want to teach, I love teaching, but I also want to do MORE. As Sharon Lynch wrote, "the science education community needs to 'think bigger' if it is going to play a role" (2009, p. 49) in enacting reform to ensure social justice, equity, and the development of intellect in our young people, but what is my role? I would like help from the group brainstorming ways to impact change, how does one even decide what issues or ideas or systems to begin working on/with/in? What advice is there in navigating this transition, should I make one? Can I stay in the classroom and work on this without my compromising my standards of teaching because my time is divided elsewhere, etc.? Many of you have been through this and I would like to gather your experiences and advice and learn from them.

This indecision's bugging me
If you don't want me, set me free
Exactly who I'm supposed to be
Don't you know which clothes even fit me?
Come on and let me know
Should I cool it or should I blow?

Fostering Reflective Self-Critique with Preservice STEM Teachers

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

Vexation

LET ME BEGIN BY CONFESSING MY INCREDIBLE GOOD FORTUNE AS A UNIVERSITY-BASED TEACHER EDUCATOR. On almost every dimension, I have stumbled into a situation that even I could not have imagined. This is not to say that things are perfect -- but moving closer to perfection is exactly what I hope to do. The good stuff begins with a fulltime program assistant who is tirelessly delighted to find her way through each and every bureaucratic maze. With a small program in a gorgeous location, I have no difficulty recruiting the very best colleagues from the main campus to teach in my little STEM Teacher Education program. In addition, I have complete administrative control ranging from admissions to passing out diplomas at graduation. Finally, because we are so self-sufficient we avoid scrutiny from those who are our ostensive supervisors. We fly through accreditation and each program grand lands a job before July arrives. Those are the glorious conditions of my workplace. Let me share some relevant details about the actual teacher preparation program.

Each June, a dozen post-graduates begin coursework having either just completed a STEM undergraduate program or transitioning from a STEM career -- as a research scientist, a field engineer, etc. An occasional candidate has done some substitute teaching but for the most part, very few have stood in front of a classroom of adolescents and delivered science or math lesson. Our summer classes run for 7 hours per day, 4 days a week for six weeks: General Methods, Learning Theory, Instructional Technology and Literacy in the Content Area. The second six weeks continues the intense pace: Social Foundations, Science or Math Methods, Teaching Special Needs … and a Clinic Experience in a combination of summer school classrooms and academic "camps." After only a dozen weeks attending their first education course, my STEM people begin a full semester of student teaching. They attend back to school professional meetings with host teachers and are in the classroom greeting students as they arrive on the first day of school. Then during the final semester in spring, they are assigned to schoolwide internship culminating with a thesis-style report as their capstone. This post-student teaching experience echoes the benefits to first year teachers' effectiveness (Boyd, Grossman, Lankford, Loeb & Wyckoff, 2009) and supplies vital exposure to systems thinking and includes exposure to leadership problems and practices. Yes, eleven months in total -- never enough time for field experiences.

During the first two cohorts, the student teaching videos produced in the fall were accompanied by superficial commentary. While the videos themselves are well produced, the reflections were anything but revelatory. The preservice teachers had difficulty commenting on their teaching practices. Also, they seemed incapable of offering deep analyses of student work collected during those videoed lessons. Clearly the summer phase of the program failed to show them how to synthesize material across multiple courses into self-critical professional educator personas. I believe the preservice teachers showed reasonable regard for the students as people -- not a minor accomplishment since most were placed in settings far more demographically diverse than what they had previously experienced. On the other hand, I suspect they didn't value the learning processes of the students. It was almost as they thought I was asking about the garnish on the soup -- whereas I was striving to have them attend to the complete entrée. Beyond giving them more practice with responding to feedback and producing critique (Stone & Heen, 2014), I couldn't help but wonder whether this was something developmental that I was unable to accelerate.

One another nettlesome event from last year's cohort was a frequent complaint about disrespectfulness from high schoolers. I suspect a large part of this was because the student teachers were expecting the students to be grateful that such smart and dedicated people were trying to teach them math and science. My suspicion is that the student teachers were not exhibiting sufficient regard for their students -- as capable individuals who had individual resources that were not being leveraged during lessons. In other words, my hunch is that in the disrespect arena that the student teachers started it -- with a small twist on deficit thinking in that the preservice teachers brought a lot to the classroom whereas the youth did not. I think all of these issues are related and need to be addressed. Because my future teachers are overly concerned about controlling students and defusing potential disrespect, I think a tacit concern about power exists. But rarely do preservice teachers recognize that power struggles are largely within their realm of influence. My hope is that preservice teachers adopt the goal of channeling, coordinating, constructing the human and material resources in STEM classrooms such that power is used to realize greater equity and access to science, math and engineering (Hand, Penuel & Gutérrez, 2012)

That becomes the essence of my Vexation: ***How can I better support my future STEM teachers to become more attentive to student learning outcomes by seeing the relationships to their teaching practices, moves, strategies, and beliefs?***

Fostering Reflective Self-Critique with Preservice STEM Teachers

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

Venture

WITH THE CURRENT COHORT, WE ADDED MORE RECORDING OF THEIR TEACHING DURING THE SUMMER. My hunch is that the camera's eye will enrich the performance-centric, memory-impinged understandings about their lessons (Schieble, Vetter, & Meacham, 2015). During general methods had them edit the video (as a sense-making practice) and then prompted them to identify various instructional moves (specifically student feedback) within the footage. We arranged individual interviews of high school students in summer school in order to identify the resources the kids would bring to a STEM classroom (as a culturally responsive variant of "elicting students' ideas c/o Ambitious Science Teaching). We afforded tag-team teaching during a middle school STEM summer program. And they delivered microteaching lessons to their peers. We worked toward providing tools and templates for self-assessing rather than leaving them to their own devices to self-evaluate. For the first lesson where they practiced behaviorist theory implementation, they were prompted to identify their actual use of feedback (as opposed to just praise) and identify opportunities missed where feedback would have been advisable. During misconception interviews with summer school students, they assessed their ability to elicit students' prior understandings (Pashler et al., 2007). Also, with "Teach Like a Champion" by Doug Lemov, they were encouraged to identify their use of targeted techniques. Which is to say we have instructional practices they could witness; I'm grappling with a theoretical lens to guide their self-critiques.

I have worked with identity theory in the past, especially James Gee's (2001) combination of nature, institutional, discourse, and affinity components (Settlage, 2011). However, an identify framework does not do enough for me in this situation. To me, identity focuses on an individual in relation to a broad community, a culture, or "the system." There's just not enough attention to discursive relationships to be satisfying. Also, identity can be all agency and no structure. I have become intrigued by Latour (2005) who claims that objects have agency. I have begun thinking about the subject matter as yet another actor with a classroom: the teacher, the students, and this thing called science. I want my student teachers to form an alliance with their students to work together to subdue the content. In the process, I hope they will grow to recognize the roles they ascribe to themselves, to their students, to the subject matter. For example, I asked them to look back on videos of themselves while team-teaching science during a middle school camp. Prompts for their written reflections included:

- *As I think about my actions during these lessons, I positioned myself as … [insert metaphor]*. Replies included an announcer, an authoritative helper, a half-hearted camp counselor, a potted plant, and a meerkat: "At times I was on watch in front of the class standing tall, or on my hind legs, giving students knowledge. Other times I was foraging for food, or circulating the room looking for student learning."
- *I realize that I used my "power" to put the students in certain positions in relation to our STEM topics. …*
- *As I compare who I would like to be as a STEM teacher with what I noticed from the videos, I cannot help thinking about what I need to do during student teaching…*

To me this felt like a good start. The preservice STEM teachers saw myriad flaws in their practices but recognized those as tendencies they could monitor and minimize during student teaching. In addition, the problems they noticed with students' misbehavior, inattentiveness, indifference were perceived as originating in the pre-service teachers' lesson planning and implementation.

Now they are student teaching, many in richly diverse settings that are generally supportive of students and novice teachers. They have others who will formally evaluated them on four occasions this semester and a retired principal will meet with them weekly during the Wednesday night seminar. They know that I plan to visit them (in a non-evaluative capacity) in part so my letters of recommendation include reports about their ongoing work with children in science and math classrooms. I will also be with them during Spring semester to advise and guide them while they work with other university faculty to conduct research and development work. But those interactions are wide open and virtually limitless. And with only 9 future STEM teachers in my care, anything you might suggest won't be constrained because of numbers.

I am seeking your professional opinions about what we've accomplished so far and suggestions about next steps over the next six months. This is not a formal investigation and I'm not trying to conduct research on my own advisees. Instead, I want to move them closer to an ideal condition as sensitive, attentive, and determined STEM teachers.

Teacher Professional Development informed by the Socio-Cultural Dynamics: The Case of Climate Change Education

Asli Sezen-Barrie, ***Towson University***

MY WORK LOOKS AT TEACHERS' ROLE IN PROGRESSION OF SCIENTIFIC DISCOURSE in sociocultural environment of classrooms has gained a new direction with my interest in Climate Change Education. The Intergovernmental Panel on Climate Change (IPCC) released the fifth assessment report on September 27, 2013 with new evidence on the climate system and human impact on a changing climate. Combining the new data from direct measurement and remote sensing from satellites with the previous measurements, the panel came to a certain conclusion that "Warming of the climate system is unequivocal…" (p. SPM-3). Although there is still an ongoing political debate and resistance by the skeptics, the U.S. Global Change Research Program identified the guidelines for climate literacy (2009) and National Science Foundation's Climate Change Education Partnership (CCEP) Program started an initiative to create an infrastructure for educators. The Next Generation Science Standards (NGSS) became the first standards that included "Climate Change" as one of the core concepts (NGSS Lead Staes, 2013). Despite the hypothetical and empirical research studies on what and how students should learn climate science concepts during K-12 education (e.g., Shepardson et. al., 2009; Mohan, Chen & Anderson, 2009), there remains a dearth of studies about in-service teachers' learning of climate science topics. With the MADE CLEAR project (Maryland and Delaware Climate Change Education Assessment and Research funded by NSF), we are working with middle school science teachers to support their learning and teaching of underlying concepts and epistemic practices associated with climate science.

During the last three years, we have designed and implemented Professional Development (PD) for 25 science teachers from Maryland and Delaware and with a varying teaching experience and science background. The activities of the PD program included:

- Presentations and videos about the underlying concepts of climate science by climate scientists
- Investigations that focused on scientific practices of data modeling and interpretation and argumentation
- How to use online curriculum and assessment resources on climate literacy
- Virtual feedback during the school year

The overarching goal of the project can be explained with the honeycomb model in Figure 1. We believe that blending the multidisciplinary content with epistemic practices of the field and sautéing this mixture with an effective implementation will make the meal tasty for the guests at the table. We recognized the distinct features of a climate change unit such as requiring multi-disciplinary content knowledge and understanding scientific practices of data modeling and interpretation and scientific argumentation. Although climate science requires use of other scientific practices, these seemed more problematic for teachers. In a "Scientific Argumentation on Climate Literacy" survey, we saw that teachers had a hard time using all relevant evidence to support their claim and that they couldn't differentiate reasoning from evidence. Our content knowledge assessment tools showed that a majority of teachers misinterpreted the graphs climate scientists publish to inform the public. We also aim to make our PD sustainable by creating a support mechanism during classroom implementation which will be informed by formative assessment practices. As a result of the professional development activities, we have seen that teachers integrated climate change into school curriculum, developed more sophisticated conceptual understanding, gained familiarity with scientific investigations, and increased their awareness of the socio-cultural aspects of climate change.

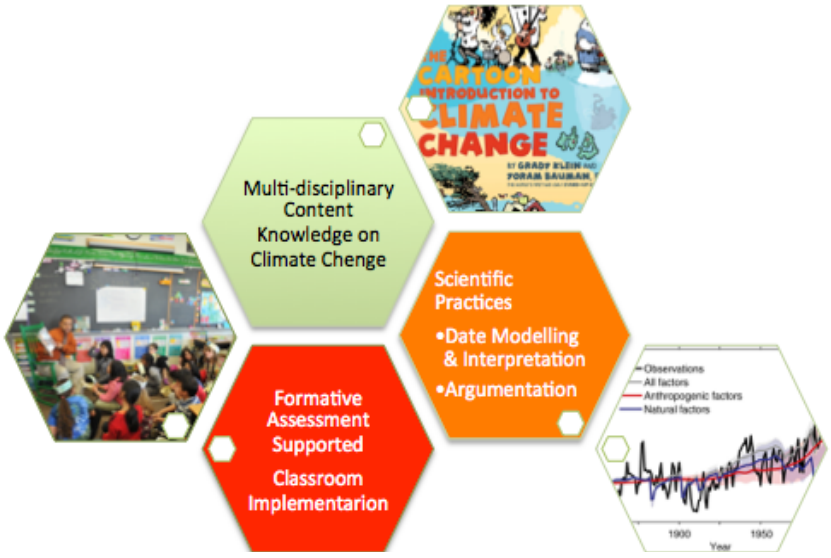

Figure 1: The honeycomb model of study.

Teacher Professional Development informed by the Socio-Cultural Dynamics: The Case of Climate Change Education

Asli Sezen-Barrie, ***Towson University***

Vexation

DESPITE THESE POSITIVE OUTCOMES, THERE ARE TWO ASPECTS OF THE STUDY THAT VEX ME. First, we couldn't give teachers a chance to develop an integrated understanding of scientific practices and core conceptual ideas. This is important for classroom implementation since NGSS requires students to progress in conceptual, epistemic and social dimensions. Scientists in our team presented the underlying concepts and a separate investigation was carried out with teachers without much focus on how the scientific knowledge can be constructed through these investigations. As Ford (2008) argues, we need to construct knowledge in the way scientists practice and that will prevent us from rote memorization. It is on the other hand challenging for climate scientists in our team to create their authentic laboratory environment in professional development sessions. They can't use the same equipment and they need to present many years of work in a limited amount of time.

A second problem was the lack of a support system for individual teachers informed by the formative assessments. Although our project had virtual PD sessions with all teachers who have attended the workshop over three years, this didn't help us understand the impacts sociocultural dynamics of schools and classrooms on the implementation of climate change activities.

Venture

My venture will have two goals. One is to find better ways to collaborate with scientists to communicate the underlying concepts blended with scientific practices. In other words, I aim to find engaging ways to teach multidisciplinary science content to the teachers as they are practicing science. To achieve this, I need to do a systematic review of successful scientists and educator collaborations. It is important to understand that most of the climate science research is criticized by its methods – domain specific ways of doing science (Skeptical Science, 2013). Therefore, scientist-teacher collaboration should help teachers experience and understand unique aspects of climate science such as historical interpretation of data as in amounts of CO2 in the ice cores. To respond to the concern related to the feasibility of activities, I also plan to review major curriculum sources to choose activities that will allow teachers and students to practice knowledge construction. Then, we can get teachers' comments on the activities and evaluate which result in better learning outcomes.

Second is to create a sustainable support mechanism for teachers while they are transforming their learning of climate science into their lesson plans and further revising their activities. Research on teacher education suggests linking student and teacher learning for improved professional development. This is mainly because teachers are expected to show increased students outcomes (e.g Fishman et. al.) Teachers might be more motivated to continue their involvement in professional development activities that they can clearly see their students' improvement. Inspired by Furtak's studies on using learning progressions in teacher education (2009, 2012), my goal is to work on case studies and create a PD model informed by learning progressions. Learning progressions (LPs) are defined as "descriptions of the successively more sophisticated ways of thinking about a topic that can follow one another as children learn about and investigate a topic over a broad span of time'' (NRC, 2007, p. 205) Furtak's model of PD utilizes formative assessments to support teachers observe their students' learning progressions on natural selection while linking curriculum, instruction and assessment. In a similar way, we are planning to work with teachers to create a climate science unit and related formative assessments. These formative assessments will consist of both written and spoken discourse because it is only moment to moment interaction in the classroom that can give us an extensive evidence of what and how students are learning (Bell and Cowie, 2001). During the PD sessions, teachers will reflect on and discuss their practices by using digital video editing. In order to achieve this goal, I have the following questions for the guests at the dinner table:

1. How can I evaluate the multidimensionality of science teachers' understanding of climate change?
2. What are the elements (researchers, equipment, logistics, connections) of creating an effective support system for middle school science teachers in order to students learning progress towards more sophisticated understanding of climate science?
3. How can I make this support system a sustainable model where these teachers create a community in their classrooms and schools?

University + Museums Educators Working in Partnership: Refining Our Research Agenda

Lara Smetana, ***Loyola University Chicago***

Vexation

Loyola University Chicago's *Teaching, Learning, Leading with Schools and Communities [TLLSC]*) initial teacher preparation program represents a bold new approach to initial undergraduate and graduate teacher preparation. TLLSC follows a site-based apprenticeship approach that integrates academic knowledge with authentic teaching and learning experiences (Ball & Forzani, 2009; Zeichner, 2009) within a variety of Chicago contexts. Moving teacher preparation out of the confines of the university, teaching and learning take place primarily in partner schools and community spaces (e.g. museums, community organizations, cultural and social service institutions, local government) where university, school, and community partners share the responsibility of preparing PK-12 teachers to serve students from diverse backgrounds. Approximately 80% of program instruction takes place away from the university and includes time with a combination of university faculty, PK-12 classroom teachers and their students, and community partners including museum and other "informal" educators. For example, regardless of their specific area of specialization, all teacher candidates (TCs) have multiple opportunities to work with educators from several of Chicago's museums beginning in their first semester when TCs begin to explore the varied, school- and non-school-based contexts where teaching and learning occur. Here, the study of learning and development theories are brought to life as TCs consider how these theories inform the design of museum spaces and program offerings. Elementary education and secondary science TCs continue to have in-depth experiences in subsequent years with those museums that have science as part of their educational mission). Here, for example, they explore a range of inquiry-based educational programs and acquire strategies, resources and supports which they can apply in their future classrooms to increase student learning.

As described in my Crossroads 2014 paper, preparing teachers with, not just in, local schools and communities has both necessitated a shift in the way that my colleagues and I think about our roles in teacher education and opened up incredible opportunities for professional development. The initial work described and discussed at my Crossroads session last year around the goal of creating spaces for continued conversation about the meaning of teacher preparation in true partnership with schools and communities has indeed taken off and is going strong, far exceeding my expectations. Our collaborative working group celebrated a one-year anniversary this summer. Comprised of a growing group of university faculty, museum educators and doctoral candidates, the group serves as a space for us to collectively reflect on our ongoing work (challenges and accomplishments, our place within the broader TLLSC program and partnership network, etc.) and craft future directions for our group and our efforts. The group also serves as a space to study ourselves and our efforts, and to consider ways to creatively disseminate findings to varied audiences. My Crossroads Vexation & Venture this year is about this last point – investigating and explaining our progress thus far and toward realizing longer-term goals. Here, I want to be cognizant of the fine line between research and evaluation. Certainly evaluation of the success of our programmatic efforts will take place, but the focus of this V&V is about a research agenda around those efforts including where the research fits within the science education literature base. I see this as a valuable area of research because, despite the strong interest in informal science institutions, out-of-school spaces and experiences, there is limited research about efforts to integrate such spaces and experiences into teacher preparation. In the teacher education literature, 'clinical sites' most often refer specifically to PK-12 classrooms. The existing literature on teacher preparation collaborations with out-of-school science primarily describes short-term efforts around highly specific purposes (Avraamidou, 2014; Kisiel, 2012). Additionally, despite universities' increasing desire, or at least their recognition of the need, to engage in partnerships as a means to fulfill civic responsibilities, there are limited examples of partnership networks (i.e. involving multiple types of stakeholders) and of university-school-community partnerships that address a broad range of educational goals (Walsh & Backe, 2013).

Venture

Moving forward, I feel that we need a strong theoretical and conceptual base to situate our work and the accompanying research within. How does this help to inform our research efforts and make what we learn meaningful to a larger audience, including but not limited to the science education community? I also feel compelled to study this partnership, with the primary end goal of having a positive influence on PK-12 students and their families and communities, from a systems perspective. That is, what might we learn from by stepping back and considering how our efforts fit within the TLLSC teacher preparation program and its broader university-school-community partnership network, as well as within the Chicago museum and informal education community? The diagram on the next page outlines my currently thinking. I am eager for feedback from Crossroads colleagues about the following broad questions:

- ***What frameworks might we consider situating this work within? What literature should we consider?***
- ***What open, pressing questions might our unique partnership be well poised to address?***

University + Museums Educators Working in Partnership: Refining Our Research Agenda

Lara Smetana, ***Loyola University Chicago***

What do we know about the formation, sustenance and outcomes of successful university-school-community partnerships? Bringle, Officer, Grim and Hatcher (2009) describe partnerships as ideally developing "out of relationships and result in mutual transformation and cooperation between parties. They are motivated by a desire to combine forces that address their own best interest and ideally result in outcomes greater than any one organization could achieve alone (p. 43-4). From this, my mind immediately went to social capital theory (Coleman, 1988; Putnam, 2000), which explains that there are intangible resources and other assets existing within social systems such as schools, universities, neighborhoods and other types of communities. Moreover, these resources can be accessed through interpersonal relationships and can affect change within and outside of that social system. While transformation of all parties might be an ultimate goal, what does progress toward this look like? Here, Noam and Tillinger's (2004) framework for describing and explaining different typologies of partnership relationships might be useful: Discovering overlapping interests (functional); Joining forces (collaborative); Developing an inclusive system (interconnected); Changing all partners (transformational). As we investigate the development and continued growth of our partnership, including factors that contribute to (or hinder) success, and the realized and potential influences on and outcomes for multiple parties, what other frameworks might we draw upon? What other literature might we consider? Are there other intriguing questions?

Of the three research sub-strands illustrated above, the first (influences on TCs) feels most clear, as it builds on the existing, yet limited, body of literature described previously. In a current manuscript in progress, we report on evidence that TCs reveal a deepened understanding of how and why teachers might connect learning experiences in school and out-of-school learning environments, an increased awareness of museum resources (including mentor relationships and pedagogies) to leverage in future teaching practice, and a shift in thinking about science and science learning, including where learning happens, what learning is, and teachers' and other educators' roles in supporting learning.

Theoretical & Conceptual Frameworks	**Influences on Teacher Candidates**
Understanding and investigating university-school-cultural partnerships around (science) teacher preparation ▪ social capital (Coleman, 1988; Putnam, 2000) ▪ communities of learners (Lave & Wenger, 1991) ▪ mutual benefit & transformative partnerships (Bringle et al., 2009; Kruger et al., 2009; Noam & Tillinger, 2004)	▪ science and science teacher identities ▪ instructional practices ▪ conceptions about museums and community as partners in education **Influences on Educators** ▪ our work (understandings, beliefs, practices) ▪ our institutions' perspectives on teacher education ▪ fields of science teacher education & museum education **Influences on Youth & Schools** ▪ youth learning opportunities ▪ youth perceptions about science, informal science institutions ▪ teacher practices

In regard to the second path, we recognize that in many ways we are redefining our work as educators, including what teacher education and preparation involves and where it takes place. Here, the body of literature dedicated to the so-called 'third space' that exists for teachers turned teacher educators working in the space between universities and schools (e.g. Williams, 2014) feels relevant. This literature documents the complexity and challenge of shifting from a classroom teacher to a university-based teacher educator particularly as more teacher preparation programs incorporate more school-based clinical experiences. There are also perspectives of professional identity that account for an individual dimension of professional being as well as a collective dimension related to an individual's sense of belonging to particular professional groups or communities (Davey, 2013). Perhaps the notion of a 'third space' and the professional identities that develop in this space could help to frame the complexities of working within and between the spaces of university, informal science education, traditional teacher education, and partnership-based teacher education? What other perspectives and literature might we pay attention to and be able to contribute to?

Thinking about influences on youth and schools, there are certainly overlaps with the questions we ask about TCs. Given the group's goal of increasing access to museum resources (again broadly defined, beyond spaces and stuff) and opportunities, we might also be adding to the literature about perceptions about inclusivity and exclusivity in ISE (Dawson, 2014). What pressing equity questions might our unique partnership network be best poised to address? What other perspectives and literature do Crossroads colleagues recommend looking at? What other questions might we explore?

Creating a Culture of Reflection and Action Based on Evidence of Preservice Science Teacher Learning

David Stroupe, ***Michigan State University***

Vexation

SCIENCE TEACHER EDUCATORS HAVE GRAPPLED FOR A LONG TIME WITH QUESTIONS ABOUT THE EFFECTS AND EFFECTIVENESS of learning opportunities provided to preservice teachers in methods courses and other settings in a preparation program. At the root of these questions lay knotty issues about *evidence*. Policymakers, professional developers, and scholars have not been able to agree on what qualifies as evidence that preservice teachers have learned anything. In part, the debates reflect confusions or simply lack of recognition about the theoretical issues (i.e., what do we mean by "learning to teach" to begin with?). There are legitimate complexities in identifying the ways in which teacher learning expresses itself in instructional practice that may appear at unpredictable moments across long periods of time. In addition, the debates reflect political realities of the contemporary reform context, as stakeholders try to ascertain what professional learning activities are necessary given the complex realities of schools (do we want to prepare teachers to be "change agents" or to survive in the current testing system?) (Gee, 2001; Peressini et al., 2004; Richardson, 1994; Wilson & Berne, 1999).

Debates about evidence of preservice teacher learning are particularly meaningful for me because I take seriously the mandate put forth by Cochran-Smith & Lytle (2009) to embrace an "inquiry stance" towards my methods courses and research. A central tenet of an "inquiry stance" is that any teacher should purposefully examine their instruction, analyze and reflect on the evidence they collect, and take action to adapt instruction based on the analysis of the evidence. While this work is valuable to me, there are few opportunities within the field of science education (and teacher education) to discuss with colleagues the evidence we collect about preservice teacher learning because of multiple constraints (time, history, disciplinary divides, and beyond). Yet we know that a primary critique of teacher preparation lies at the core of these constraints – how can we claim that we are preparing novices for professional work when we, as a field, cannot articulate a shared stance about teacher learning?

A lack of conversation about evidence of teacher learning troubles me for two reasons. First, university-based teacher preparation has seemingly stagnated since we lack a shared understanding of "what counts" as evidence of learning. Consequently, science educators miss opportunities to collectively study and adapt preparation programs. Second, some teacher preparation programs are shifting away from framing learning as knowledge acquisition towards defining learning as participation in practices. Subsequently, one might expect the evidence we collect and use to make claims about teacher learning should come from performance-based assessments rather than tests and surveys. However, opportunities to develop and implement such assessments are rare.

Given the lack of conversations as a field, creating a culture in which we make programmatic decisions based on shared evidence seems unlikely, at least in the near future. Thus, my vexation can be summarized with several questions:

- How might I, with colleagues, press for change in field that believes it is producing good teachers?
- How might I, with colleagues, disrupt this system to instill a culture that values evidence-based reflection and action?
- Who gets to decide "what counts" as evidence of preservice teacher learning and why?

My Venture(s)

MY VENTURE HAS TWO PARTS: A MICRO-VENTURE AND A MACRO-VENTURE. The micro-venture involves the creation of a team of colleagues that express interest in establishing a shared definition of preservice teacher learning. The core of a shared definition involves conversations about evidence, both in terms of progression towards participation in the teaching profession, and issues of methodology (i.e., what evidence do we need to collect, how will we collect it, and how can we analyze it). The establishment and support of this team would likely be voluntary, and could have the potential for external funding after collection and analysis of some pilot data. A key feature of this group is that it should include people from *different* universities who share an interest in teacher preparation. Working across universities is important in order to address a primary critique of education research (and teacher preparation) – that claims made by one group in a certain setting cannot apply to another setting given the context-specific nature of teaching and learning.

The macro-venture is a bigger challenge – I want this group of colleagues to help change the narrative of science teacher preparation around "what counts" as evidence of preservice teacher learning. My inspiration for a grassroots group to reshape a narrative comes from philosophers of science (Sandra Harding, Helen Longino, and more) who call for "science from below." I will explain this term, and then relate it to my venture. Typically, people in positions of authority determine science practice, including standards for evidence. Since practice is created by powerful people and then disseminated to other (and less powerful) practitioners, "science from above" reflects the values and objectives of an elite few. While seemingly benign on the surface (after all, someone has to decide "what counts"

David Stroupe, ***Michigan State University***

as practice and everyone has values and objectives built into their decisions), the decisions are often tied to external interests (money, politics, and beyond). A frequent critique of "science from above" is that such work constrains innovation by placing value on some research while ignoring other forms of inquiry. To push back on a science created by and for an elite group of people, some philosophers call for "science from below." This notion of science is that people typically excluded from decisions about practice should have a voice about disciplinary work. Therefore, "science from below" is inherently bound to, and shaped by, people without typical power and authority.

I appropriate the language of "science from above" and "science from below" when thinking about evidence of preservice teacher learning and creating a culture that is reflective and takes action to meet preservice teacher needs. Often in teacher education, an elite few decide "what counts" as evidence of teacher learning. Sadly (in my opinion), such elites have little experience in teacher preparation and actual classroom instruction. Too often, such people have ties to special interests. For example, the recent movement to link student test scores on standardized assessments to teacher preparation programs has the backing of policymakers and testing companies, but lacks support from people who prepare teachers and who do not stand to gain financially from new laws. The pressure of politics affects deans and department chairs that must comply (on some level) with ill-informed definitions of learning and evidence.

My macro-venture, then, is to work with colleagues to create counter-narratives about evidence that pushes back on claims about learning based on gains on various knowledge assessments. As previously noted, characterizing and evaluating evidence of teachers learning around practices is difficult. However, such work is necessary to reclaim national discussions about the professional preparation and work of science teachers.

I view my two-pronged venture as staring at different points in time (collaborative group first, then discussions in the field), but not as a linear process. In other words, as the small group wrangles with definitions of learning and evidence, we can work with (and get pressed by) the field to refine out thinking. In turn, our findings can provide evidence to the field, as well as catalyze conversations, about taking a collective stance about preservice teacher learning.

Ideas I have considered

There are three primary ideas I have considered thus far when thinking about the problem of evidence. First, there is a growing movement in education research to build and study Networked Improvement Communities (NICs, see Bryk et al., 2010). While useful, this research is nascent in science teacher education literature. Second, the emergence of Design Based Implementation Research (DBIR, for example, see here: http://researchandpractice.org) has noted the futility of research-based efforts to shift state and national conversations since most efforts do not include the voices of multiple (and crucial) actors – for example, we tend to leave out the ideas of teachers and principals when making recommendations for research about teachers and principals. Therefore, any research I undertake (including the possible NIC) should include practicing teachers and other district actors as key partners. Third, initiatives such as the edTPA (http://www.edtpa.com/) are trying to fill the void of evidence given the lack of practice-based assessments. While the edTPA could be a possible avenue to explore, I am wary of any initiative that partners with a company (Pearson, in the case of edTPA) to make claims about teacher learning when there is a clear monetary stake in having the assessment appear successful.

Questions for My Colleagues to Consider

Clearly my ventures are of varied scales and represent different levels of difficulty to enact. I would appreciate my colleagues at Crossroads to consider the following questions:

- What can we treat as "evidence" of professional learning, and in what ways does this evidence capture what might be going on as teachers engage in professional learning activities?
- What conceptions of professional learning underlay the evidence? What other assumptions are at work?
- What is likely to count as evidence of professional learning to particular stakeholders?
- What scholarly tools (measures, research designs) are likely to be helpful in gathering evidence of professional learning? What scholarly problems have researchers yet to solve?
- How and why can a small group of colleagues elevate their concerns to the field that believes it is innovative?
- How can "evidence from below" shape state and federal policy?

Sociology of Earthquake: Does science matter to children of Nepal?

Bhaskar Upadhyay, ***University of Minnesota***

Venture

THIS IS ONE OF THE MOST DIFFICULT WRITING AND, FOR NOW, I NEED TO MUSTER TO WRITE IT. I lived through the April 25, 2015, earthquake in Nepal attempting ways to save two of my niece's five years old daughters in a matter of sixty seconds and luckily all turned out to be happy for my family but not so happily for thousands of fellow Nepalease. The massive 7.9 quake took away so many precious lives, thousands of years of cultural heritage, peoples' homes, and livelihood but left behind lifelong psychological and physical trauma. One of the most painful legacies of this earthquake that I witnessed in Nepal was the psychological trauma that children had to endure. Many were getting used to living with the fear of another quake and for many this will become a life-long trauma that somehow needed to be managed. For example two boys who were almost the same age as my son were so traumatized by the earthquake that they refused to enter their homes no matter how much the parents and elders tried. In Nepali culture you obey your parents and elders wishes and most of the time without question. They just dug their heels on the ground and at the same time wailed so painfully that the parents just gave up. No matter how much everyone in the family cajoled, enticed, and encouraged, the kids refused to budge. This was the power of the earthquake… This is the psychological and social price that the earthquake has exacted on the children of Nepal and adults were not immune to it either…After experiencing the solid earth underneath me move day-in and day-out for sixteen days, I spontaneously would jump up and ready to head to the exit...One can only imagine how people in remote villages of Nepal where out of 36,000 homes only 5,000 were left standing but even these homes were unsafe to inhabit.

With this backdrop, I am just at a loss what I should share with my friends and colleagues at this year's Crossroads. Should it be about publishing my work in science education journal pages, book chapters, just plain conversations about science and its connections to social and cultural aspects of learning and doing science and the most importantly for what purposes and for who.

I went to Nepal, my home country, to continue my venture on the issues of food security and how science curriculum could build a young generation of Nepalese to be aware of and to do something about food security in their communities and for themselves. But this venture morphed into another venture with the earthquake- the venture of helping people in need for food, water, and shelter on April 25, 2015. I admittedly also ventured into finding out, first hand, what happened to the iconic cultural heritage of Nepali culture. When I saw the destruction and complete obliteration of many of the temples and monuments from the old parts of Kathmandu, I felt a loss, a big chunk of me as a Nepali disappeared or will stay disappeared for many years. I lost a part of who I was…it made me tear up and a sense of overwhelming sadness… made me wonder just how much was gone and how long this would take before things got restored. Similarly I lost many neighbors and their family members and families of my friends who I knew well and also those I didn't know well. These were very painful loses for everyone and the most tragic to the closest families.

In my work as a science educator and researcher, I have always viewed science through the sociocultural and social justice lens. My venture has been all about finding lived socio-cultural experiences and knowledge that would make science learning meaningful and may be provide useful answers to those who needed during these times. I have always argued, as have many other scholars in this area of science education, that without strong connections between students' own experiences and their identities, there is very little value seen in learning science. Without these connections science learning can become very pedantic and academic without much to see oneself in it. This is exactly what I experienced while talking to adults, elders, and children in Nepal about the earthquake. I was not surprised that science had very little usefulness in reducing fear in people about the timing of the next earthquake and what it could do to them, their loved ones, their homes, their cultural heritage, and their lives. I felt completely helpless when I could not assure many adults and children that science has no answer for the timing of the earthquake, the duration of the earthquake, the size of the earthquake (strength), the direction of the earthquake, and the most importantly, the end of the earthquake, including the aftershocks. This raised the questions of what should science education do for people and how do we engage people in science knowledge that so that they are less traumatized by the events of this kind and build confidence in science knowledge and learning.

Sociology of Earthquake: Does science matter to children of Nepal?

Bhaskar Upadhyay, ***University of Minnesota***

Vexation

WHAT BECAME VERY CLEAR TO ME AFTER SPENDING SIXTEEN DAYS IN NEPAL EXPERIENCING THE EARTHQUAKE, aftershocks and its impact on people's social, cultural, psychological, and economic lives, was that science education had to connect to people in ways that made them feel that science knowledge aided them to be safe, helped them rebuild their lost cultural heritage, identities, and better future from these kinds of very uncertain natural events. To the contrary, in Nepal, for children, science did not assure them that they would be safe and would be able to go into their homes and feel comforted. How would one explain to a six years old child how and why knowing and learning about the mechanisms of the earthquakes would make them safe? How would one explain that when the earth beneath them moves, it is a natural phenomenon-just happens, live with it, no need to worry? How would one explain that science is just a bunch of probabilities but somehow they needed to trust its authority during this time? When children and adults were seeking certainty from science, science failed them miserably or people failed to heed science (as Nepal sits at the boundary of two geological plates – Indian and Tibetan). When a newspaper in Nepal published the news that "geologists and earthquake scientists new that 7.3 aftershock on May 11 was inevitable" many people in Nepal commented that "after the fact anyone can be an expert; these were bunch of useless scientists; why would a scientist not tell people that this was coming?; what a bunch of [no good scientists]." How would science educators and science teachers reach out to people who saw science differently? I can only imagine the anguish, helplessness, and fear that people, children in particular, had to brave in Haiti or those who lived under the fear of Ebola where many people saw science as another gawker. Similarly in the case of Nepal, science looked like a helpless knowledge that couldn't reach out to people to help them. How would a science education researcher talk to people in Nepal that reached out to them rather than provided "probabilistic and uncertainty filled answers'?

My research in food security in Nepal has raised some very basic questions about doing research in a place that is temporary for a researcher and about understanding an issue that is designed and conceptualized in a foreign place and a foreign country. My own research on food security in Nepal was conceptualized by a group of us – geographer, sociologist, and a science educator – who were living in the US with no input from the community where the research would be carried out or what kind of food security issues the community wanted to know and to understand about. What happens to the research, the researched, and the researcher when events as tragic as the earthquake, epidemic, flood, hurricane, and war intervene and where should I locate as a researcher these events in my research or does this matter? Who are the researchers helping with their research? What happens to people's sense of who they are as a cultural, racial, and ethnic group in the research? In this Crossroads I need more of your calm and at-a-distance view about how a science education researcher and educator should go about presenting and writing on such topics.

A Case Study of the Intersection of School Leadership, Social Justice and STEM Curricula and Enactment in a High Needs High School in Belize

Noemi Waight, ***University of Buffalo***

Vexation

THIS VEXATION ADDRESSES INTERNATIONAL RESEARCH WORK CONDUCTED IN BELIZE, a small English speaking country in Central America. More specifically, this work was organized to examine two related themes: the role of school leadership and leadership for social justice; and the relationship of school leadership and curriculum development and enactment of STEM in a high needs high school in Belize. When we set out to do this work, we wanted to ensure that these constructs were defined in the context of Belizean schooling. For example some of the major goals involved defining notions of high needs in developing countries, understandings strategies that guide decisions of leaders in high needs schools, understandings how leaders are prepared to conduct their work, notions of inequality that pervade educational systems across the globe, understanding how social justice is operationalized in these setting, examine how school leadership conceptualizes the development and goals of STEM curricula and, how STEM related domains are enacted in practice.

In this V&V I specifically address how school leaders conceptualized curricula related to Integrated Science, Ecology, and Technology courses and how science and technology lessons were enacted. In this regard, the following research questions guided this study:

(a) How did school leaders conceptualize the goals of curricula related to Integrated Science, Ecology and Technology courses? What were the roles of school leaders in this context?

(b) What are the primary characteristics of the enacted curriculum in terms of content, pedagogical approaches, resources and assessment?

(c) What were students' experiences with STEM related courses?

To understand the context of work, I provide some brief history and information on Belize. Belize is the only English speaking country (a former British colony), situated on the Caribbean Sea, south of Mexico and east and north of Guatemala in Central America. Belize with a population of approximately 358,899 became an independent nation in 1981. At least 46.3% of he population represents children and youth of school age (1-19 years). The birth rate, infant mortality rate and life expectancy is respectively: 25.14/1000; 20.31/1000; 68.49 years. According to the 2013 economic summary the GDP/PPP 3.083 billion with an unemployment rate of 15.5%. The major ethnic groups in Belize include Mestizo (48.7%), Creole (24.9%), Maya (10.6%), Garifuna (6.1%) and Other (9.7%). Sources: The World Factbook; Center for International Research; U.S Bureau of the Census.

The education system in Belize has its roots in the English system, but most recently, this system has evolved to reflect elements of the US education system. Most of Belize's public schools operate under church-state partnerships; the Catholic Church is the dominant church partner. To a lesser extent there are also partnerships with Methodist and Anglicans. According to Naslund-Hadley, Alonzo, and Martin (2013), even with heavy investment by the government, education access, quality and equity was rather dismal. In fact, only 45% of secondary school age children attend high school (the regional average attendance is 80%). The report specifically cited that equity at the secondary level is an important issue because children from wealthier families are twice as likely to be enrolled.

The study design was a naturalistic case study that involved classroom observations of STEM sessions, semi-structured individual interviews with school leaders (principal, managing director, projector director, and counselor), science and technology teachers, and students. Data were collected over a period of three months and triangulated to provide a holistic understanding of the case (Yin, 2009).

Our preliminary findings revealed that the major indicators of high needs in the Belize context included: lack of local and national fiscal support, student performance, drop out/graduation rates, language barriers, and teacher quality. Lack of infrastructure, school resources and issues of space also delineated notions of high needs. School leaders emphasized four main themes that defined their

roles: facilitate opportunities for access to school and community-based experiences; prepare students to contribute to the economics of their community (e.g., tourism); provide professional development for teachers; and, address administrative and logistical issues.

For example, in terms of contributions to community productivity, Katie, explained that the school offered access to help students become productive and contributing members of the community:

> ***Another example is we have entrepreneurship classes and because we are a fund-raising school we incorporate our need to fundraise with our educational goals of teaching the kids how to be entrepreneurs. And so [in] the small businesses we have the kids learn about in their class is kayaking, biking and fishing.***

Pedro, a student also supported the value of learning valuable skills: "When I first started here [Academy], I had P.E., which was scuba diving and I got certified for advanced scuba diving. That's very good because maybe in the future, if I want to work as a tour guide, I already can dive. I just need to get certified as a tour guide."

For school leaders expectations for STEM curriculum reflected the global urgency of preparing youth for STEM careers. While science and technology resources were limited in the context of schooling (e.g., lack of science lab and equipment), science inquiry experiences were provided through field-based investigations and school-community project-based experiences related to integrated science and ecology. For example, while school leaders did not have access to programming experts, they provided access to students via online programs such as Hour of Code, a curriculum available in California schools. In addition, while the school did not have access to a science lab, scientific experiences were provided via field labs. For example, students conducted ecology labs through evening and weekend internships with the fisheries department. In this respect they learned about ecological interdependence of various species of aquatic organisms. Scientific knowledge was thus very contextual.

Consistent with the above expectations for the STEM curriculum, enactment followed a blend of didactic modes of teaching with a focus on note taking and hands-on classroom activities and field investigations. For example, students were involved in a field activity to explore field-sampling techniques used by Biologist to estimate population. This involved going out into the field to identify and tag soldier crabs. This approach reflected contextual understandings of scientific phenomena.

Venture

THE FIRST PHASE OF THIS WORK REVEALED SOME INTERESTING FINDINGS. As we move forward with the second phase of data collection, it would be helpful to receive feedback on other themes and subthemes related to the intersection of school leadership, curriculum and STEM teaching and learning. What other important questions should be guiding this work? What theoretical frameworks may best inform the context of this work? While Belize is the context of this initial work, we hope to expand this research to include other countries in the Caribbean and Central America. Currently, the literature reflects minimal research in these countries. So one of the outcomes of this project is to propose a model that could guide future work.

Some potential approaches to extend this work may involve use of auto-photography (Moreland & Cowie, 2005) as a methodological approach. This will involve students using cameras to capture images that represent their notions of social justice and science and technology experiences. This approach is significant since most of the science experiences involve informal learning during after school and weekend related activities. This data can serve two purposes: First, from the perspective of research it can help to broaden our notions of how students understand science and technology in high needs contexts and second, it can serve as visual data for school leaders who purposely to seek to elevate the status of STEM learning among high school students. Second, this work cautioned the notion of transfer of STEM conceptualizations into non-western contexts. Most of the STEM related research has been conducted in North America (US and Canada), Europe, and Asia. Representation from poorer countries in Latin American and the Caribbean has been completely disregarded. This brings to bear the following questions: How do we negotiate these established notions of what it means to participate and prepare for STEM learning and career readiness? How are these notions of STEM represented in the colonized history of countries like Belize, the Caribbean, and Latin America? One suggestion here is to use Testimonio as a methodology to unpack how Belize's colonized history may inform STEM approaches at the high school level.

Cooking up a Research Agenda: What Comes Next?

Brooke Whitworth, ***Northern Arizona University***

Vexation

A VITAL COMPONENT OF NATIONAL EFFORTS TO INCREASE STUDENT LEARNING IS THE PROFESSIONAL DEVELOPMENT OF SCIENCE TEACHERS (Desimone, Porter, Birman, Garet, & Yoon, 2002; Hewson, 2007; PCAST, 2010). Professional development programs have the ability to make powerful and sustaining changes in teacher practice (Desimone et al., 2002; Kennedy, 2005; Luft, 2001; Supovitz & Turner, 2000) resulting in an increase in student achievement (Buczynski & Hansen, 2010; Desimone, 2009; Johnson, Khale, & Fargo, 2007; Wallace, 2009). School districts play a key role in providing professional development to teachers and are often the principal providers of professional development (Birman et al., 2007; Pianta, 2011). District administrators experience pressure from states, school boards, teachers, parents, and their communities to show improvement in student achievement. Thus, curriculum and instruction administrators are constantly searching for reform efforts that will improve student learning and satisfy these multiple stakeholders. The individuals often responsible for implementing professional development and supporting science reform efforts for curriculum are science coordinators.

Many large school districts employ a science curriculum administrator – such as a science coordinator, director of STEM education, or science supervisor – who is responsible for coordinating science curriculum at the district level. However, many small or rural school districts lack the financial resources to hire science curriculum administrators. In these districts, the task of coordinating curriculum may fall to a global curriculum and instruction director or a science lead teacher. These individuals, who work at the district level, can see the whole picture, whereas a principal focuses on building level issues. Regardless of who is responsible for the science curriculum within a district, the role these individuals play is critical to improving student achievement (Marzano, Waters, & McNulty, 2005).

While the characteristics of effective professional development are well documented in the literature, (Desimone, 2009; Hewson, 2007; Luft & Hewson, 2014), little research explores the individuals who plan and conduct professional development and how they do it (Luft & Hewson, 2014). PCAST (2010) recommended research investigate the role of educational leadership in science to gain further knowledge about how educational leaders are supported through professional development programs. Despite initial evidence supporting the critical nature of the district science coordinator role (Madrazo & Hounshell, 1987; Perrine, 1984), the research in this area is meager and outdated.

As part of my dissertation work and research, I began to investigate the district science coordinator role by working on the following studies and papers:

- A review of the literature situating the role of district science coordinators within the research on professional development, teacher change, and ongoing leadership for teacher change (Whitworth & Chiu, 2015). This review suggests professional development models should integrate district science coordinators as essential components and not just peripheral, contextual factors.
- A national survey of district science coordinators to further define the professional responsibilities of coordinators, provided insight into the role of a science coordinator, and specified the prevalent types and focus of professional development coordinators' desire (Whitworth, Maeng, Wheeler, & Chiu, In Review). This study leveraged Leithwood's (2012) core leadership practices to characterize various professional responsibilities and activities coordinators engage in to develop professionally. From this study, it was evident coordinators, as leaders, spend most of their time ***redesigning the organization*** and ***setting directions***.
- Two studies evaluated different outcomes of the Virginia Initiative for Science Teaching and Achievement (VISTA) New Science Coordinator Academy (NSCA) professional development. One study indicated science coordinators' understandings changed and were maintained a year following the NSCA (Whitworth, Bell, Maeng, & Gonczi, In Review). However, their understandings were not fully reflected in their practices. This study was informed by McLellan's (1996) situated learning perspective. The second study further investigated how coordinators designed and implemented professional development and their practices in supporting science teachers' instruction (Whitworth, Maeng, & Bell, in review). This study was guided by Blasé & Blasé's (1999) Reflection Growth model for instructional practices. The results revealed coordinators support teachers in a variety of ways, using varied

Brooke Whitworth, ***Northern Arizona University***

professional development strategies, and their practices were aligned with the majority of the NSCA goals. The teaching background of science coordinators and district characteristics were identified as critical factors that influenced their practices.

These studies are important as they represent the few examples of current research investigating the role of a science coordinator and the impact science education leadership may have on teacher change and student learning. I am at a point where I am considering not only next steps in my research agenda, but also what perspectives I should consider as I pursue that work. I have struggled with situating my work as there is so little research on this level of district leader.

Venture

A NATURAL PLACE TO SITUATE MY WORK MIGHT BE WITHIN DISTRIBUTED LEADERSHIP (Spillane, Halverson, & Diamond, 2001). In this framework, I would work toward identifying the leadership tasks and functions, the task enactment, the social distribution of the task enactment, and the situational distribution of the task enactment as science coordinators work within their districts. This would require further research into the macro and micro tasks science coordinators engage. I believe many of the macro tasks have been identified through the survey study. The VISTA NSCA papers have identified some of the micro tasks coordinators engage in but this would require further inquiry. The second step would then be investigating more fully the ways in which science coordinators enact these leadership tasks within their districts, again I believe I have some insight into how coordinators enact these practices from previous studies, but a more in-depth focus is needed to understand these tasks as they unfold. One aspect my work has not addressed thus far that using this framework would allow, is the social distribution of the task enactment. Identifying the leaders who enact tasks together may be difficult, as this work would be at the district level and school level. Depending on the size of the district that could encompass an overwhelming number of individuals, including: superintendent, other curriculum leaders, principals, assistant principals, curriculum specialists, etc. Finally, this framework would allow me to delve into the situational aspect of coordinators work: the artifacts, tools, and organizational structures coordinators work with and within. I believe this framework has a lot of value and if applied to science coordinators at the district level may provide a lot of rich description about how coordinators think and act to improve teacher learning and student achievement.

While this area seems appropriate, another approach I am considering is related to my own background. I grew up in Japan, living there from ages 7-18, as such I identify as a Thrid Culture Kid (TCK) (Pollack & Van Reken, 2010). A TCK is an individual who has "spent a significant period of their developmental years in a culture outside of their parents' passport culture(s)" (Pollack & Van Reken, 2010, p.xi). Having lived such a significant part of my life in Japan, I regularly struggle with merging my Japanese host culture with my American passport culture. In reflecting on my own life and the work of science coordinators, I have come to believe that coordinators are a type of TCK, they are in essence Third Culture Leaders. The majority of these individuals begin their careers as K-12 science teachers, but as they transition into administration they take on new roles and learn to adapt to a new administrative culture. However, unlike principals or superintendents, coordinators often have little power to enforce policies and have no input into employment decisions or evaluations. Yet, they are administrators and are perceived as having power; thus, placing them outside of the teacher culture. Therefore, I think they exist in this third space, where they are not teachers anymore and they are not high-level administrators. One of the issues I see with this is that often coordinators are the only individual in their position within their district and they have very little interaction with or support from others like them. The professional isolation and lack of meaningful support for coordinators are characteristics common to TCKs as they move from their host culture to their passport culture. I think there may be some affordances to identifying coordinators as these Third Culture Leaders who work to bridge the two cultures of teaching and administration in order to support teacher learning and student achievement. This may provide more insight into how to better support and develop individuals for this type of role.

As a result of this conference I hope to gain wisdom and guidance from others who have successfully developed their own research agenda and found unique ways to situate their research. As someone new to the profession, I will appreciate any thoughts or ideas you can provide.

Developing Respect for the Ingredients: Balancing the Intellectual and Emotional Connections in an Environmental Literacy Course

Rachel Wilson, ***Appalachian State University***

Vexation

I'VE BEEN TEACHING AN ENVIRONMENTAL LITERACY COURSE FOR OVER FOUR YEARS. Every time I finish the course I think about my personal and professional goals and whether or not I'm meeting them. The goal of the course for me has been that students understand how we scientifically know things about the state of the environment for a few reasons: a) because it's an opportunity to get more science into their elementary education degree requirements; b) because my belief is that it's harder to brush away or ignore the scientific evidence for what we know about how the environment works; and c) this may be the last formal education they ever have related to environmental topics. However, I think that if I only focus on the science aspects of the environment, and only on science activities that they could do with their students to address environmental topics, then I've left out a crucial compelling leverage point: that the environment connects with every aspect of our lives. Coming to recognize that our lives as we know it are only possible because of our use of mostly limited environmental resources has been an emotional realization for me personally. I think that this connection to the environment and the emotional response that comes with thinking of these issues in a personal light is an important goal for me as a teacher of this content – more important than whether or not my students have a particular attitude toward an environmental solution.

At the conclusion of each semester I ask myself: What understandings of the environment are these elementary education majors walking away with? Do they feel a more personal connection to the environment? Do they recognize that their daily choices have an effect on the health of the environment, whether that effect is positive or negative? Are they walking away with an understanding that the natural world provides the ingredients that make up every thing they depend on? These are partially intellectual questions, but they have a significant personal/social/emotional component to them.

I have been collecting student work from the course now for two years to try to answer some of these questions for myself. I do not necessarily think that I can answer each of the above questions adequately. But I believe that collecting and reviewing student work can help give me a sense for how my pedagogical choices may change students' responses to the material. For example, I spent class time towards the end of the spring semester facilitating an activity that was an exploration of the carbon cycle: how it functioned, how certain types of activities release carbon to the atmosphere, and where carbon gets sunk or stuck in the cycle. Then I had the class play the Thingamabob game (Bigelow, 2002) to explore how businesses contribute carbon to the carbon cycle and how capitalism is set up to allow corporations to ignore their carbon footprints. Then I presented the students with scientific evidence of carbon dioxide concentrations increasing in the atmosphere due to human activity and evidence of warming being correlated with increased carbon dioxide concentrations. We also looked at evidence of consequences of warming trends (glacier calving in the Arctic) and predictions for climate change based on increased carbon dioxide concentrations for mega-droughts in the mid-west and southwestern United States (Cook, Ault & Smerdon, 2015). In the fall I ended class with the article *How to Be a Climate Hero* (Schulman, 2008) and a video clip from the documentary *Dirt!* in which Wangari Maathai tells a folk tale about a hummingbird fighting a forest fire–both of which offer hopeful messages related to our responses to environmental degradation issues.

This semester, our class got interrupted and so we didn't make it to the hopeful activities–we ended on the doom and gloom of scientific evidence supporting that human activity is resulting in a significant perturbation of the climate system. The class's emotional state at the end of class was low–the lowest I've ever sensed a class emotional state in this course. Quiet, drawn faces and blank stares. At the time I was not sure how to evaluate their emotional states. Were they experiencing resistance to the data or to the idea that humans have any influence on the climate system? Were they feeling despair or sadness at the state of the climate disruption based on the data? Or were they tired at the end of the semester?

We did pick up with the hopeful activities on the last day of class, but I still was not sure I knew how to evaluate their emotional response during the previous class meeting. When I talked with each student during finals week in our individual final reflections, at least three students without prompting brought up that they had been thinking about climate change and how they needed to know about it. One mentioned that she had had a fight about it with her fellow Republican boyfriend because she felt it was not a partisan issue and he did.

My initial thoughts about this past semester are that maybe having that wait time between thinking about the scientific evidence and a message of hope was useful in having to think about what it meant that the world as they know it was already changing significantly. That the place they depended on might not always be the same. However, having an emotional response because you're starting to make connections is one thing, but I do not want to instill an emotional reaction of utter despair, which could be debilitating (Gifford,

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2011), or one of fear, which could result in feeling disengaged (Tzou & Bell, 2012). I do want students' responses to the environment to be one of connection and empathy with other living organisms (Sobel, 1999), and appreciation for how the environment can provide for our needs.

So my vexation is: How do I bring in the emotional with the intellectual content in the course without promoting a sense of fear or despair about the state of the environment? How do I help them cultivate an appreciation for the ingredients of our lives that we take from the environment while recognizing that we do not have an unlimited supply?

Venture

IN *THIS CHANGES EVERYTHING: CAPITALISM VS. THE CLIMATE*, NAOMI KLEIN (2014) ARGUES THAT UNREGULATED CAPITALISM without government policies that require businesses to account for environmental costs and their use of "the commons" has brought us to the current state of the climate, in which 2014 was the warmest year in recorded history. The idea that has been haunting me since I read her book is that individual consumer choices alone are not going to change the state of the environment. What is so bold in Klein's (2014) book is her assertion that climate change is a social justice issue, and the action needed to make an authentic and meaningful change in our progression towards higher concentrations of carbon dioxide in the atmosphere is a people's protest against the status quo on the scale of the Civil Rights movement.

What does this mean for my venture? I am not going to stand in front of students and advocate that they need to become politically involved–that would feel like proselytizing. I do want my venture to create a context in which students are supported in decentering their environmental identities and examining tensions of meeting their needs and how their choices impact the natural environment. And I want to avoid having the resolution of their tensions being only consumer oriented, individualistic solutions.

Sobel (1999) has advocated for a developmental progression in environmental education that moves from a place of *empathy* to *exploration* of the environment, before asking students to think about social action. I would like to weave all three of these themes more intentionally into the course to help me bring in the emotional with the intellectual. I see empathy for the natural world as a necessary emotional foundation upon which to build a meaningful tension for students. I see exploration as a way to help students recognize our dependence on natural resources and the current state of environmental degradation. And I see *social action* as a means for introducing hope and perhaps a sense of empowerment for students to help them out of feelings of despair.

To address empathy, I created a Nature Journal assignment to encourage students to develop empathy for a particular place in nature and help them develop a personal connection. The Nature Journal assignment asks the students to choose a spot "in nature" and visit it throughout the semester to document what they observe using their four senses, write some interpretations of their observations, as a naturalist would, and write a personal reflection on each visit.

To address *exploration*, I have been contemplating an assignment in which students would investigate the answer to an environmental resource question, such as: What is the most environmentally friendly source of protein that humans could eat? (for nutritionally focused students) or What is the most environmentally friendly fabric material that humans could wear? (for fashion focused students). By investigating the environmental resources used to make a product that they use fairly often, I want them to develop an appreciation for the resources provided by the natural world and think about their own personal impact on the environment.

I am unsure of how to meaningfully and appropriately integrate a ***social action*** component. I have students read ***Hoot*** (Hiaasen, 2002) because it is a young adult book with environmental social action themes. We examine sustainability projects related to our class content that include both a social justice and environmental theme. As a part of our service-learning program in elementary education, my students participate in 20 hours of service connected to our course. In addition to having students interact with elementary aged kids in environmental activities, I do ask students to participate in stream or creek clean-ups and trail maintenance projects. I am not sure that students truly connect these activities to the idea of social action and would love feedback on how others have thought about including social action components into their teaching in appropriate ways. I am afraid I am going in too many directions and am not creating a streamlined narrative for students to follow.

From Crossroads participants, I would like feedback on how to meaningfully use Sobel's (2002) framework to help preservice elementary teachers decenter their environmental identities and in productive and hopeful ways.

Pondering Academic Culture

Nate Wood, ***North Dakota State University***

Vexation

I HAVE BEEN THINKING A LOT ABOUT ACADEMIC CULTURE. What got me thinking in this direction was some autoethnographic work I started a few years ago, which opened my eyes to ways it impacts me personally. However, those growing recognitions are now fueled as much by new teaching responsibilities, which position me to more overtly socialize emerging scholars, and new service responsibilities, which recruit me to participate in (re)creating norms, values, and power structures in my institution.

To illustrate, a conflict between academic culture and other facets of life comes into sharp relief for me in dealing with time and scheduling. As an academic, one of my current classes meets each Thursday, 7:00-9:50pm, final grades are due by midnight on May 19th, and other meetings seem to come in endless 1-hour blocks (usually having been set days, weeks, or even months ahead of time). However, at home, on my small hobby farm, thinking about time in that linear, rigid, quantized way just does not work. For example, following the cold, west-central Minnesota winter, my 1/4-mile long, dirt and gravel driveway thaws, on average, around the beginning of April and needs to be graded shortly thereafter in order to prevent ruts and giant puddles forming. I could, I suppose, schedule driveway grading for April 15 each year – but that would be stupid. Had I done that this year, I would have been choked-out by the dust cloud I would have created, because the driveway was too dry. Last year, I would have gotten stuck in the mud, because the driveway was too wet. And the year before, I would have accomplished nothing at all, because the driveway was still frozen in mid-April. And in each of these cases, I would have been spectacularly unsuccessful in maintaining my driveway – because driveway grading is one of the myriad tasks that simply must be done when the conditions are right. But as the conditions become right for those sorts of tasks, my academic calendar frequently orders me into meetings or class sessions. In this way, academic norms for thinking about time routinely come into conflict with other facets of who I am (or want to be). Cultural norms of the academe do not seem to allow much space for me to be both scholar and "farmer." Certainly, the stakes are much lower in the example I've chosen to offer here than they are for, say, my colleagues with children – particularly female colleagues with children – who routinely find themselves expected to leave parent identities at the door when they enter the university. However, I find a fascinating irony in the fact that, much like driveway maintenance, learning is another in the long list of natural processes that occurs when the conditions are right rather than when the calendar dictates. So how can it make sense for education to be scheduled on the inflexible calendar of the academe? This strikes me as the sort of paradox in which sociocultural insights might live.

I bring this growing recognition of the sorts of identity conflicts that arise in the academe to foundational courses I have been teaching to new education doctoral students. These new initiates seem predisposed to feel like becoming a scholar obligates them to leave behind treasured facets of themselves. For example, Labaree (2003) calls out an apparent cultural mismatch that confronts teachers (and, I would add, other practitioners) as they enter doctoral education: the culture of teaching/practice versus the culture of research. While I (and, I suspect, many others) see teaching and research as two sides of the same coin (i.e., scholarship), teachers/practitioners enter doctoral education suspicious of research: seeming reluctant to take on a researcher identity – as if that would require them to jettison their teacher/practitioner identities. Yet I have heard doctoral students praise a particular faculty member as being an excellent teacher in one breath and, in the next breath, claim they just can't think in terms of research like that same faculty member. How is the belief maintained that they must chose to be either teacher or researcher in the face of evidence that (some) faculty members can be both/and?

Finally, as I write this, I am wrapping up service on a search committee to find a new dean for the college in which I work (a college of human development and education). I have been astounded by how little thought most of the candidates have given to what it is we do in higher education. Most seemed to treat teaching, research, and service as orthogonal tasks – and struggled to articulate meaningful purposes for doing any of these things. One was completely stymied by the question "why do we bother to do research?" The academic in me was flabbergasted by this – but the researcher in me was fascinated. How can someone hoping to lead a college comprising approximately 100 faculty members, at a land-grant, research extensive university have so much trouble articulating purposes for the widely professed, tripartite mission of higher education? Is academic culture so entrenched – so taken for granted – even our leaders no longer think about why our tribe does the odd things we do?

Naturally, being a nerdy academic, I now have a compulsion to study this. I suspect part of my motivation grows out of the post-tenure blues – and I am trying to (re)discover meaningful reasons to persist on the academic treadmill. But I have a sense that there is something to be gained by better understanding academic culture – if nothing else it should help better prepare doctoral candidates for what lies ahead. However, while my work over the past decade or so has drawn my attention to sociocultural issues in education, I am not trained as a sociologist or anthropologist. I would like to think that, with the right amount of ignorance, one can see old problems in

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new ways. But that sort of fertile naiveté can be difficult to differentiate from complete ignorance (especially one's own). I know others have studied academic culture – and my knowledge of that literature is far from comprehensive (so if am I bumbling ignorantly through well-worn conceptual terrain, I would like to know that – before I waste a lot of time reinventing an existing wheel). I have seen literature addressing disciplinary cultures, the two cultures of the academe (hard sciences vs. social sciences and humanities), and dominator (e.g., whitestream or patriarchal) cultures in academia. While all of these ways of understanding sociocultural issues in higher education certainly bear on academic culture, they don't seem quite to satisfy my curiosity. I am drawn to Latour's (1986) classic work in "Laboratory Life" as my inspiration for the project I have in mind. He entered a (very highly regarded) biochemistry lab, as a participant-observer. And what he found in the mundane, day-to-day minutia of what the scientists did (as opposed to what they professed to do) revealed the complex and nuanced social dynamics of what the scientists themselves saw as an objective process of discovery. But Latour was an outsider to the lab he studied. Already being an insider, how can I cultivate the fertile naiveté needed to understand academic culture?

Venture

THE DRIVEWAY EXAMPLE ABOVE DERIVES FROM MY AUTOETHNOGRAPHIC WORK. That is the genesis of my venture. But my energy lately has been directed more toward conceptualizing the problem: **trying to figure out what it is I really want to ask so I can think about how to investigate it**. I have cast a fairly wide net, but there are two key ideas that have surfaced as perspectives that might help me make the now familiar academe strange to me once again: fragmentation and sacredness.

Adams [see: www.youtube.com/watch?v=GGuxcJa5-tw] argues that western universities privilege the intellectual and (grudgingly) admit the experiential, but deny other ways of knowing (see also: www.tapestryinstitute.org/ways-of-knowing). Similarly, Toulmin (2001) illustrates how western modern science has come to over-rely on rationality to the expense of other ways of reasoning. It points to an intellectual elimination diet, of sorts, that leads to malnourished and fragmented ways of knowing/being in the academe. And I see this as being (at least partially) at the root of identity conflicts I mentioned above.

Where I think my venture is headed is toward investigating mythic ways of knowing in academe. To be clear, I do not use "myth" in the pejorative sense – as it is commonly (mis)understood in western cultures. I am referring to the stories, metaphors, and other art forms which embody a worldview and convey important truths held by members of a cultural group. Even if we profess not to literally believe our cultures' myths, we act on them as though we do. Or, rather, they freight-in the norms and values we need in order to act. For example, I would argue U.S. universities (and many others around the world) are constructed on the myth of the independent scholar: a heroic figure whose bold discoveries are progress toward more complete and true understanding. Indeed, much of this language commonly appears in university policies (e.g., for promotion and tenure) and mission statements and is embodied in rituals and ceremonies like comprehensive exams and graduation. Rituals and ceremonies, in this light, are often sacred – and this leads me to Pirsig's (1974) description of the university as the *church of reason*.

In short, what I think I want to do is study the church of reason: its myths, metaphors, sacred texts, rituals, ceremonies, and so forth. As I get started in this endeavor, I am looking for critical feedback, ideas, and maybe even partners. I am especially looking for good questions to ask. Here are a few that I am currently pondering:

- What myths/metaphors (implicitly) underlie ways we understand (and do) higher education?
- What do we treat as being sacred (ceremonies, texts, rituals, etc.) that might be fruitful sites for study?
- What other sort of things do we do out of habit, without thought about why we do them – or for which our professed purposed do not match (or justify) our actual behavior?
- Who/what might be fruitful data sources?
- How is knowledge fragmented in and by the academe? (Surely, academic silo-ing is important here, but might there be other structures/processes to attend to as well?)
- Am I too hung up on my own context: a research university? Should I attend to ways academic culture plays out at other institution types as well?

The Uninvited Guest

Erin Furtak, ***University of Colorado Boulder***

There's a Monty Python sketch from 1969 called "The Visitors" that begins with a couple, Victor (Graham Chapman) and Iris (Carol Cleveland) settling in for an evening alone. Two glasses of wine sit on the coffee table, and soft piano music plays on the Hi-Fi as Victor takes Iris' hand. Suddenly, there is a knock at the door, and Victor rises to answer – and get rid of – whoever is there. In pops Arthur (Eric Idle), a jolly chap that Victor met at the pub several years prior, finally making good on Victor's disingenuous invitation to pop in for a drink.

Arthur replaces the mood music with the Washington Post March as the bell rings again, and Arthur admits a bickering couple, Brian (John Cleese) and Audrey (Terry Jones). Soon Brian makes advances on Iris and sends her off screaming as even more guests arrive, Mr. Freight (Terry Gilliam) wearing a sparkling pair of briefs and a cape, followed by Mr. Cook (Michael Palin), a farmer with a goat in tow. Victor reaches his limit, shouting: "Look, get out all of you. Go on. Get out! Get out!"

Adam and John challenged us to take up culinary metaphors at this year's Crossroads as an extension of the conference's emphasis on participants acting as 'polite dinner guests'. But rather than slicing, dicing, and sautéing coming to mind, the culinary metaphor instead brought up for me the image of a party in "The Visitors," and my role in it as one of the uninvited guests.

The context for this metaphor is my new research project, a research-practice partnership (Coburn & Penuel, 2013), or a long-term collaboration between university researchers and a local school district organized to "investigate problems of practice and generate solutions for improving district outcomes" (p. 1). My partnership began in August 2014 when I received a cold call from a district science supervisor who had read my book on formative assessment (Furtak, 2009) and invited me to lead some professional development workshops they were planning. Intrigued, we began a series of conversations that ultimately led to an NSF proposal and a RAPID grant that was funded in January of this year.

In the past, my research projects have involved a different type of partnership. These relationships have usually been at my initiation, where I have sought out like-minded teachers willing and interested to work with me. These collaborations have lasted years, establishing and building upon deep trust that involved both the teachers and me taking risks and searching for new solutions or, as my mentor Susan Elko described it, "learning with and from each other."

My new research-practice partnership positions me in a different way: a visitor to teachers' classrooms invited by district leadership. The focus of the project is on supporting science teachers in designing, enacting, and interpreting the results of common formative assessments (Ainsworth & Viegut, 2009; Furtak, 2012) linked to the scientific practices in the *Next Generation Science Standards*. We have set an ambitious agenda to leverage once-monthly late-start professional development meetings to set in motion teachers' engagement in the iterative process of designing these assessments together, which then would be taken up in their school-based professional learning communities (PLCs). My team and I help to co-plan and co-facilitate both the late-start professional development meetings, as well as the school-based PLCs, and then follow teachers into their classrooms to watch them enact the formative assessments, and meet with them later to discuss what they did, what they learned about student thinking and practices, and what they plan to do next.

My Vexation

Entering this research project in full partnership with school district leaders has positioned me as an Uninvited Guest in the teachers' classrooms. I am one of many visitors to the teachers' classrooms that are a part of our modern public school system. At its essence, the classroom learning relationship is about a teacher and student, deeply engaged with each other, responsive to each other's requests and needs, and mutually committed to learning. However, public school districts add layers upon layers of interlopers into this relationship: up to 30 (and sometimes more) students to which the teacher must also attend, instructional coaches, administrators, district instructional leadership, and many others.

At the same time, many of these visitors are responsible for enacting and enforcing Race to the Top-linked accountability structures that tie teachers' job security and salary increases to the evaluations performed by these visitors. In Colorado, these

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structures are delineated in Senate Bill [SB]10-191 (Colorado General Assembly, 2010), which requires teacher tenure be granted on the basis of three consecutive years of demonstrated effectiveness, and revoked after two consecutive years of ineffective ratings. These ratings of effectiveness are based on classroom evaluations and measures of student learning, including standardized tests.

Around the same time that 10-191 became law, science teachers in Colorado were surviving a rapidly changing landscape for standardized testing. The Department of Education adopted new Model Content Standards for Science, triggering a series of transitions as it phased out the Colorado Student Assessment Program (CSAP, last administered in 2011), took up the Transitional Colorado Assessment Program (TCAP, 2012-2014), and ultimately adopted the computer-based Colorado Measures of Academic Success (CMAS, first administered in 2015).

Along with these changes in standardized testing came district efforts to place in teachers' hands measures of student learning that would determine their effectiveness ratings. In the district in which I am conducting the project, part of the teachers' effectiveness rating is proposed to be based on district and school-determined student learning objectives (SLOs). The plan is that teachers will work together in their PLCs to identify sets of progressive learning objectives, come up with common assessments to trace student learning along those objectives, and then those changes in student learning would be factored into their effectiveness rating.

Now enter the Uninvited Guest. As the project got underway, I introduced teachers to our professional development model, the Formative Assessment Design Cycle (Furtak & Heredia, 2014), which is intended to guide the work of their PLCs in setting learning goals, exploring student thinking, designing assessments, and reflecting on those results to guide their instruction. While teachers were nothing but kind to me and engaged in the Design Cycle in professional development sessions, I realized that what I was asking them to do was very similar to the procedure the district was suggesting they use for setting SLOs in their PLCs to be used as part of their evaluation for SB 10-191.

Perhaps as a result, I encountered a deep distrust of me as an outsider introduced by yet another visitor, the district instructional leaders. Teachers were wary of participating in the project, expressing concerns about the types of data I might be collecting, and with whom those data would be shared. They were if unsure I was a person they could trust, and who could blame them, given the accountability climate in which they work?

My Venture

"The Visitors" unfortunately does not end well for Victor and Iris. After repeated advances by Brian, Iris runs off; Victor objects and Brian pulls out a gun and shoots him. In a way, this tragic ending to the sketch feels like a worst-case metaphor for teaching and learning: the visitors, intending to support teachers' classroom practices, end up permanently disrupting the learning environment.

My venture, in the midst of this research-practice partnership, is to 'take back' classroom assessment with the teachers. I want to be a visitor that can be trusted, and to engage with them in the work of improving classroom practice and student learning through formative assessment design. In essence, my venture is to change my role from Uninvited Guest to Collaborator. However, the path toward this goal is unclear, and to date I have only one year of funding available to even begin this journey.

I hope to engage with the Crossroads attendees in how to go about this transition. What are entry points for me? What modest goals are accomplishable in this timeframe? How can I simultaneously partner with teachers and district leaders?

Bibliography

Abrams, E., Yore, L.D., Bang, M., Brayboy, B.M.J., Castagno, A., Kidman, J., Lee, H., Villanueva, M.G., Wang, M.H., Webb, P., & Yen, C-F. (2014). Culturally relevant schooling in science for indigenous learners worldwide. In S.K. Abell & N.G. Lederman (Eds.) *Handbook of research on science education* (2nd ed.) (pp. 671 - 696). Mahwah, NJ: Lawrence Erlbaum Associates.

Aikenhead, G.S., & Jegede, O.J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching*, *36*(3), 269-287.

Ainsworth, L., & Viegut, D. (2006). *Common formative assessment: How to connect standards-based instruction and assessment*. Thousand Oaks, CA: Corwin Press.

Alexander, M. (2010). *The new Jim Crow: Mass incarceration in the age of colorblindness*. New York: New Press.

Allen, C. D., & Penuel, W. R. (2014). Studying teachers' sensemaking to investigate teachers' responses to professional development focused on new standards. *Journal of Teacher Education*. doi:10.1177/0022487114560646.

Arroyo, A. T. (2014). A composite theoretical model showing potential hidden costs of online distance education at historically black colleges and universities: With implications for building cost-resistant courses and programs. *Online Journal of Distance Learning Administration*, *17*(1)

Au. W. (2007). High-stakes testing and curricular control: A qualitative metasynthesis. *Educational Researcher*, *36*(5), 258–267

Avraamidou, L. (2014). Developing a reform-minded science teaching identity: the role of informal science environments. Journal *of Science Teacher Education*, (7).

Bakan, D. (1966). The test of significance in psychological research. *Psychological Bulletin*, *66*, 423-437.

Ball, D. L., & Forzani, F. M. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education, 60*(5), 497–511.

Bell, B., & Cowie, B. (2001). The characteristics of formative assessment in science education. *Science Education*, *85*(5), 536-553.

Berkman, M. B., & Plutzer, E. (2015). Enablers of doubt: How future teachers learn to negotiate the evolution wars in their classrooms. *Annals of the American Academy of Political and Social Science*, *658*(March), 253-270.

Bertrand Jones, T., & Osborne-Lampkin, L. (2013). Black female faculty success and early career professional development. *Negro Educational Review, 64*(1-4), 59-75.

Bigelow, B. (2002). Capitalism and the environment: The Thingamabob game. In B. Bigelow & B. Peterson (Eds.), *Rethinking globalization: Teaching for justice in an unjust world* (p. 287-291). Milwaukee, WI: Rethinking Schools Press.

Birman, B., Le Floch, K. C., Klekotka, A., Ludwig, M., Taylor, J., Walters, K., Wayne, A., Yoon, K. (2007). *State and local implementation of the No Child Left Behind Act: Vol. 2. Teacher quality under NCLB: Interim report.* Washington, DC: U.S. Department of Education; Office of Planning, Evaluation and Policy Development; Policy and Program Studies Service.

Blase, J. J. and Blase, J. R. (1999) Principals' instructional leadership and teacher development: teachers' perspectives. *Educational Administration Quarterly*, *35*, 349–378.

Boyd, D. J., Grossman, P. L., Lankford, H., Loeb, S., & Wyckoff, J. (2009). Teacher preparation and student achievement. *Educational Evaluation and Policy Analysis*, *31*(4), 416–440.

Bringle, R. G., Officer, S. D. H., Grim, J., & Hatcher, J. A. (2009). George Washington Community High School: Analysis of a partnership network. *New Directions for Youth Development*, 41–60.

Brotman, J.S. & Moore, F.M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching*, *45*(9), 971- 1002.

Brown, J.C. (2014). *Designing for culturally responsive science education through professional development*. Unpublished doctoral dissertation, University of Florida.

Brown, M. W. (2002). *Teaching by design: Understanding the interactions between teacher practice and the design of curricular innovation*. Unpublished doctoral dissertation, Northwestern University, Evanston, IL.

Bryan, L.A. & Atwater, M.M. (2002). Teacher beliefs and cultural models: A challenge for science teacher preparation programs. *Science Education*, 86(6), 821 -839

Bryk, A., Gomez, L. M., Grunow, A. (2010). *Getting Ideas Into Action: Building Networked Improvement Communities in Education*. Carnegie Foundation for the Advancement of Teaching, Stanford, CA.

Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26,* 599-607.

Buxton, C.A. (2006). Creating contextually authentic science in a "low-performing" urban elementary school. *Journal of Research in Science Teaching*, *43*(7), 695-721.

Carlone, H. B., Haun-Frank, J., & Kimmel, S. C. (2010). Tempered radicals: elementary teachers' narratives of teaching science within and against prevailing meanings of schooling. *Cultural Studies of Science Education*, *5*(4), 941–965.

Coburn, C. (2004). Beyond decoupling: Rethinking the relationship between the institutional environment and the classroom. *Sociology of Education*, *77*(3), 211-244.

Coburn, C.E., Penuel, W.R., & Geil, K.E. (January 2013). *Research-Practice Partnerships: A Strategy for Leveraging Research for Educational Improvement in School Districts.* William T. Grant Foundation, New York, NY.

Cochran-Smith, M, and Lytle, S. L. (2009). *Inquiry as stance: Practitioner research for the next generation*. New York: Teachers College Press.

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, *94*, 95–120.

Cook, B.I., Ault, T.R., & Smerdon, J.E. (2015, Feb 12). Unprecendented 21st century drought risk in the American Southwest and Central plains. *Science Advances*, 1(1 e1400082). doi: 10.1126/sciadv.1400082

Darling-Hammond, L. (2004). Standards, accountability, and school reform. *Teachers College Record, 16*(6), 1047-1085.

Davey, R. L. (2013). The *professional identity of teacher educators: Career on the cusp?* London: Routledge.

Davis, E. A., & Krajcik, J. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher*, *34*(3), 3-14.

Dawson, E. (2014). Equity in informal science education: developing an access and equity framework for science museums and science centres. *Studies in Science Education*, *50*(2), 209–247.

Delgado, R., & Stefancic, J. (2012*). Critical race theory: An introduction* (2nd ed.). New York: New York University Press.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*, 181-199.

Desimone, L. M., Porter, A. C., Birman, B. F., Garet, M. S., & Yoon, K. S. (2002). How do district management and implementation strategies relate to the quality of the professional development that districts provide to teachers? *Teachers College Record, 104*(7), 1265-1312.

Easton, J. Q. (2013). *Using measurement as leverage between developmental research and education practice*. Invited talk given at the Center for the Advanced Study of Teaching and Learning, Curry School of Education, University of Virginia. http://ies.ed.gov/director/pdf/Easton062013.pdf

Farrington, C.A., Roderick, M., Allensworth, E., Nagaoka, J., Keyes, T.S., Johnson, D.W., & Beechum, N.O. (2012). *Teaching adolescents to become learners. The role of noncognitive factors in shaping school performance: A critical literature review*. Chicago: University of Chicago Consortium on Chicago School Research.

Fishman, B. J., Marx, R. W., Best, S., & Tal, R. T. (2003). Linking teacher and student learning to improve professional development in systemic reform. *Teaching and Teacher Education*, *19*(6), 643-658.

Flowers, L. O., White, E. N., Raynor, J. E., & Bhattacharya, S. (2012). African American students' participation in online distance education in STEM disciplines implications for HBCUs. *SAGE Open*, *2*(2), 2158244012443544.

Ford, M. (2008). Disciplinary authority and accountability in scientific practice and learning. *Science Education*, *92*(3), 404-423.

Furtak, E. M. (2009). *Formative Assessment for Secondary Science Teachers*. Thousand Oaks, CA: Corwin Press.

Furtak, E. M. (2009). Toward learning progressions as teacher development tools. In *Learning Progressions in Science Conference, Iowa City, IA*.

Furtak, E. M. (2012). Linking a learning progression for natural selection to teachers' enactment of formative assessment. *Journal of Research in Science Teaching*, *49*(9), 1181-1210.

Furtak, E. M. (2012). Linking a learning progression for natural selection to teachers' enactment of formative assessment. *Journal of Research in Science Teaching*, *49*(9), 1181–1210.

Furtak, E. M., & Heredia, S. (2014). Exploring the influence of learning progressions in two teacher communities. *Journal of Research in Science Teaching*, *51*(8), 982–1020.

Garet, M. S., Porter, A. C., Desimone, L. M., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945 .

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945.

Gay, G. (2010). *Culturally responsive teaching: Theory, research, and practice* (2nd ed.). New York, NY: Teachers College Press

Gee, J.P. (2001). Identity as an analytic lens for research in education. *Review of Research in Education 25*, 99-125.

Bibliography

General Assembly of the State of Colorado. SB 10-191 *Concerning Ensuring Quality Instruction Through Educator Effectiveness* (2010).

Gifford, R. (2011). Dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist*, *66*(4), 290-302.

Gioia, D. A., & Chittipeddi, K. (1991). Sensemaking and sensegiving in strategic change initiation. *Strategic Management Journal, 12*(6), 433-448.

Glasson, G.E., Mhango, N., Phiri, A., & Lanier, M. (2010). Sustainability science education in Africa: Negotiating indigenous ways of living with nature in the third space. *International Journal of Science Education*, 32(1), 125-141.

Goodwin, C. (1994). Professional vision. *American Anthropologist*, *96*(3), 606–633.

Gresalfi, M. S. (2009). Taking up opportunities to learn: Constructing dispositions in mathematics classrooms. *Journal of the Learning Sciences*, 18(3), 327-369.

Grossman, P., & McDonald, M. (2008). Back to the future: Directions for research in teaching and teacher education. *American Educational Research Journal*, 45(1), 184-205.

Gutierrez, K. D., & Rogoff, B. (2003). Cultural ways of learning: individual traits or repertoires of practice. *Educational Researcher*, *32*(5), 19–25.

Hand, V., Penuel, W. R., & Gutierrez, K. D. (2012). (Re) Framing educational possibility: Attending to power and equity in shaping access to and within learning opportunities. *Human Development*, *55*, 250-268.

Hargreaves, A., & Fullan, M. (2012). *Professional capital: Transforming teaching in every school*. New York: Teachers College Press.

Hewson, P. W. (2007). Teacher Professional Development in Science. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education.* London: Lawrence Erlbaum & Associates, Publishers.

Hochberg, E. D., & Desimone, L. M. (2010). Professional development in the accountability context: Building capacity to achieve standards. *Educational Psychologist, 45*(2), 89-106.

Hopkins, M., & Spillane, J. P. (in press). Conceptualizing relations between instructional guidance infrastructure (IGI) and teachers' beliefs about mathematics instruction: Regulative, normative, and cultural-cognitive considerations. *Journal of Educational Change*.

Intergovernmental Panel on Climate Change (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY.

Johnson, C. C., Kahle, J. B., & Fargo, J. D. (2007). A study of the effect of sustained, whole-school professional development on student achievement in science. *Journal of Research in Science Teaching, 44*, 775-786.

Johnson, C.C. (2011). The road to culturally relevant science: Exploring how teachers navigate change in pedagogy. *Journal of Research in Science Teaching*, *48*(2), 170-198.

Kennedy, M. M. (2005). *Inside teaching: How classroom life undermines reform.* Cambridge, MA: Harvard University Press.

Kind, V. (2009) Pedagogical content knowledge in science education: perspectives and potential for progress. *Studies in Science Education*, *45*(2), 169-204.

Kisiel, J. (2012). Introducing future teachers to science beyond the classroom. *Journal of Science Teacher Education*, *24*(1), 67–91.

Klein, N. (2014), *This changes everything: Capitalism vs. the climate.* New York: Simon & Schuster.

Kozol, J. (1991). *Savage inequalities: Children in America's schools* (1st ed.). New York: Crown Pub.

Labaree, D. F. (2003). The peculiar problems of preparing educational researchers. *Educational Researcher*, *32*(4), 13-22.

Ladson-Billings, G. (1994). *The dreamkeepers: Successful teachers of African American children.* San Francisco, CA: Jossey-Bass.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. American Educational Research Journal, 32(3), 465-491.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in U.S. Schools. *Educational Researcher*, *35*(7), 3.

Ladson-Billings, G., & Tate, W. F. I. V. (1995). Toward a critical race theory of education. *Teachers College Record*, *97*(1), 47-68.

Lamott, A. (1994). *Bird by bird: Some instructions on writing and life*. New York: Pantheon Books.

Lampert, M., Franke, M. L., Kazemi, E., Ghousseini, H., Turrou, a. C., Beasley, H., … Crowe, K. (2013). Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching. *Journal of Teacher Education*, 64(3), 226–243.

Latour, B. & Woolgar, S. (1986). *Laboratory Life: The Construction of Scientific Facts*. Princeton, NJ: Princeton University Press.

Lee, O. (2004). Teacher change in beliefs and practices in science and literacy instruction with English Language Learners. *Journal of Research in Science Teaching*, 41(1), 5-93.

Leithwood, K. (2012). Core practices: The four essential components of the leader's repertoire. In K. Leithwood & K. Seashore-Louis (Eds.), *Linking leadership to student learning* (pp. 57-67). San Francisco, CA: John Wiley & Sons, Inc.

Lemke, J. L. and Sabelli, H. (2008), Complex systems and educational change: Towards a new research agenda. *Educational Philosophy and Theory*, *40*,118–129.

Lemov, D. (2010). *Teach Like a Champion*. San Francisco: Jossey-Bass.

Lim, M., & Calabrese Barton, A. (2006). Science learning and a sense of place in a urban middle school. *Cultural Studies of Science Education*, *1*(1), 107-142.

Luft, J. A. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education, 23*, 517-534.

Luft, J. A. & Hewson, P. W. (2014). Research on teacher professional development programs in science. In In S.K. Abell & N.G. Lederman (Eds.), *Handbook of research on science education (Second Edition).* London: Lawrence Erlbaum & Associates, Publishers.

Madrazo, G. M. & Hounshell, P. B. (1987). Science supervisor: Results of research in science supervision. *Science Education, 71*(1), 9-14.

Marzano, R. J., Waters, T., & McNulty, B. A. (2005). *School leadership that works: From research to results.* Denver, CO: Mid-continent Research for Education and Learning.

McLellan, H. (1996). Situated learning: Multiple perspectives. In H. McLellan (Ed.), *Situated learning perspectives* (pp. 5-17). New Jersey: Educational Technology Publications.

Meiners, E. (2011). Ending the school-to-prison pipeline/building abolition futures. *Urban Review*, *43*(4), 547-565.

Meyer, X. & Crawford, B.A. (2011). Teaching science as a cultural way of knowing: Merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education*, 6, 525-547

Mohan, L., Chen, J., & Anderson, C. W. (2009). Developing a multi–year learning progression for carbon cycling in socio–ecological systems. *Journal of Research in Science Teaching*, *46*(6), 675-698.

Monty Python's Flying Circus. (1969). *The Visitors*. Available online: https://youtu.be/0GH7pfVvCII?t=22

Moreland, J., & Cowie, B. (2005). Exploring the methods of autophotography and photointerviews: children taking pictures of science and technology. *Waikato Journal of Education*, *11*, 73–87.

Nadeau, R., & Désautels, J. (1984). *Epistemology and the Teaching of Science a Discussion Paper*.

Naslund-Hadley, E., Alonzo, H., & Martin, D. (2013). *Challenges and opportunities in the Belize education sector*. Inter-American Development Bank, Education Division.

National Research Council [NRC]. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board of Science Education, Division of Behavioral and Social Sciences and Education. Washington, D.C.: The National Academies Press.

National Research Council. (2006). *Systems for state science assessment*. Washington, DC: National Academies Press.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.

NGSS Lead States. (2013). *Next Generation Science Standards*: For States, By States. Washington, DC: The National Academies Press.

Noam, G. G., & Tillinger, J. R. (2004). After-school as intermediary space: theory and typology of partnerships. *New Directions for Youth Development*, *101*, 75–113.

Pashler, H., Bain, P., Bottge, B., Graesser, A., Koedinger, K., McDaniel, M., and Metcalfe, J. (2007) *Organizing instruction and study to improve student learning* (NCER 2007-2004). Washington, DC: National Center for Education Research, Institute of Education Sciences, US Department of Education.

Patchen, T., & Cox-Petersen, A. (2008). Constructing cultural relevance in science: A case study of two elementary teachers. *Science Education*, 92(6), 994-1014

Pawson, R., Greenhalgh, T., Harvey, G., & Walshe, K. (2004). *Realist synthesis: an introduction*. Manchester: ESRC Research Methods Programme, University of Manchester.

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, *44*(4), 921–958.

Penuel, W.R., Fishman, B.J., Cheng, B.H., and Sabelli, N. (2011). Organizing research and development at the intersection of learning, implementation, and design. *Educational Researcher*, *40* (7), 331-337.

Bibliography

Peressini, D., Borko, H., Romagnano, L., Knuth, E., & Willis, C. (2004). A conceptual framework for learning to teach secondary mathematics: A situative perspective. *Educational Studies in Mathematics, 56*, 67-96.

Perrine, W. G. (1984). Teacher and supervisory perceptions of elementary science supervisors. *Science Education, 68,* 3-9.

Pianta, R. C. (2011). Teaching children well: New evidence based approaches to teacher professional development and training. *Center for American Progress, 11,* 1-36.

Pirsig, R. M. (1974). *Zen and the art of motorcycle maintenance: An inquiry into values*. New York: William Morrow.

Pollock, D., & Van Reken, R. (2010). *Third culture kids: Growing up among worlds*. Nicholas Brealey Publishing.

Powell, R., Cantrell, S., Gallardo Carter, Y., Cox, A., Powers, S., Rightmyer, E.C., . . . Wheeler, T. (2012). *Culturally Responsive Instruction Observation Protocol* (revised). Lexington, KY: Collaborative Center for Literacy Development.

President's Council of Advisors on Science and Technology (2010). Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future. Retrieved from http://www.whitehouse.gov/sites/default/files/ microsites/ostp/pcast-stem-ed-final.pdf

Putnam, R. (2000). *Bowling alone: The collapse and revival of American community*. New York: Simon & Schuster. Retrieved from http://bowlingalone.com/

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning?. *Educational Researcher*, *29*(1), 4-15.

Redd, T. M. (2003). "Tryin to make a dolla outa fifteen cent": Teaching composition with the Internet at an HBCU. *Computers and Composition*, *20*(4), 359-373.

Remillard, J. T. (2000). Can curriculum materials support teachers ' learning ? Two fourth-grade teachers ' use of a new mathematics text. *The Elementary School Journal*, *100*(4), 331–350.

Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research*, *75*(2), 211–246. doi:10.3102/00346543075002211

Richardson, V. (1994). Conducting research on practice. *Educational Researcher, 23,* 5-10.

Sadler, T.D., Amirshokoohi, A., Kazempour, M., Allspaw, K.M. (2006). Socioscience and ethics in science classrooms: Teacher perspectives and strategies. *Journal of Research in Science Teaching*, 43(4), 353-376.

Sandelowski, M. Docherty, S. & Emden, C. (1997). Qualitative metasynthesis: Issues and techniques. *Research in Nursing & Health*, 20, 365-371.

Schieble, M., Vetter, A., & Meacham, M. (2015). A discourse analytic approach to video analysis of teaching aligning desired identities with practice. *Journal of Teacher Education, 66*(3), 245-260.

Schulman, A. (2008, May/June). How to be a climate hero. *Orion Magazine*. Retrieved from: https://orionmagazine.org/article/how-to-be-a-climate-hero/

Settlage, J. (2011). Counter-stories from White mainstream preservice teachers: Resisting the master narrative of deficit by default. *Cultural Studies of Science Education*, *6* (4), 803-836.

Shepardson, D.P., Niyogi, D., Roychoudhury, A., & Hirsch, A. (2012). Conceptualizing climate change in the context of a climate system: Implications for climate and environmental education. *Environmental Education Research*, *18*(3), 323-352.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14.

SkepticalScience (2013). *Explaining climate change science & rebutting global warming misinformation*. Retrieved from http://www.skepticalscience.com on April 10, 2013.

Sleeter, C. (2012). Confronting the marginalization of culturally responsive pedagogy. *Urban Education*, 47(3), 562-584.

Smith, C., Snir, J., & Grosslight, L. (1992). Using conceptual models to facilitate conceptual change: The case of weight-density differentiation. *Cognition and Instruction*, *9*(3), 221-283.

Sobel, D. (1999). *Beyond ecophobia: Reclaiming the heart in nature education*. Great Barrington, MA: Orion Society.

Song, K. H. (2006). Urban teachers' beliefs on teaching, learning, and students: A pilot study in the United States of America. *Education and Urban Society*, 38(4), 481-499.

Spillane, J. P., Halverson, R. & Diamond, J. B. (2001). Investigating school leadership practice: A distributed perspective. *Educational Researcher, 30*(23), 23-28.

Stone, D., & Heen, S. (2014). *Thanks for the feedback: The science and art of receiving feedback well*. New York: Penguin Books.

Strike, K.A., & Posner, G. J. (1992). A revisionist theory of conceptual change. In R.A. Duschl & R.J. Hamilton (Eds.), *Philosophy of science, cognitive psychology, and educational theory and practice* (pp. 147-176). Albany, NY: State University of New York Press.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*, 963–980.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. Journal of Research in Science Teaching, 37(2), 963-980.

Swan, K., & Shih, L. F. (2005). On the nature and development of social presence in online course discussions. *Journal of Asynchronous Learning Networks*, *9*(3), 115-136.*John*

Tan, A. (2011). Home culture, science, school and science learning: Is reconciliation possible? *Cultural Studies of Science Education*, 6, 559 – 567. DOI 10.1007/s11422-011-9343-5

Tewksbury, R., Erickson, D. J., & Taylor, J. M. (2000). Opportunities lost the consequences of eliminating Pell grant eligibility for correctional education students. *Journal of Offender Rehabilitation*, *31*(1/2), 43.

The University of Texas at San Antonio, College of Education and Human Development, Department of Interdisciplinary Learning and Teaching [ILT]. (2015). Retrieved August 31, 2015 http://catalog.utsa.edu/graduate/educationhumandevelopment/interdisciplinarylearningteaching/

Thorne, S., Jensen, L., Kearney, M.H., Noblit, G., & Sandelowski, M. (2004). Qualitative metasynthesis: Reflections on methodological orientation and ideological agenda. *Qualitative Health Research*, *14* (10), 1342-1365.

Toulmin, S. E. (2009). *Return to reason*. Cambridge, MA: Harvard University Press.

Travis, J., Western, B., & Redburn, S. (2014). *The growth of incarceration in the United States*. Washington, DC: The National Academies Press.

Tzou, C.T. & Bell, P. (2012). The role of borders in environmental education: Positioning, power, and marginality. *Ethnography and Education*, *7*(2), 265-282.

Valencia, R. R. (2010). *Dismantling contemporary deficit thinking: Educational thought and practice*. Routledge.

Wallace, M. R. (2009). Making sense of the links: Professional development, teacher practices, and student achievement. *Teachers College Record, 111*, 573-596.

Walsh, M. E., & Backe, S. (2013). School–university partnerships: Reflections and opportunities. *Peabody Journal of Education*, *88*(5), 594–607.

Webster-Wright, A. (2009). Reframing professional development through understanding authentic professional learning. *Review of Educational Research , 79* (2), 702-739.

Weick, K.E. (1995). *Sensemaking in organizations*. Thousand Oaks, CA: Sage.

Whitworth, B. A., & Chiu, J. L. (2015). Professional development and teacher change: The missing leadership link. *Journal of Science Teacher Education, 26,* 121-137.

Whitworth, B. A., Bell, R. L., Maeng, J. L., & Gonczi, A. L. (In review). *Professional development for science coordinators: Preparation to support high-quality science instruction*.

Whitworth, B. A., Maeng, J. L., & Bell, R. L. (In review). *Exploring practices of science coordinators participating in targeted professional development*.

Whitworth, B. A., Maeng, J. L., Wheeler, L. B., & Chiu, J.L. (In review). *Critical factors impacting the role of a district science coordinator.*

Williams, J. (2014). Teacher educator professional learning in the third space: Implications for identity and practice. *Journal of Teacher Education*, *65*(4), 315–326.

Wilson, S.M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education, 24,* 173-209.

Wong, G., Greenhalgh, T., Westhorp, G., Buckingham, J., & Pawson, R. (2013). RAMESES publication standards: realist syntheses. *BMC Medicine*, *11*(1), 21.

Yin, R. K. (2009). *Case study research: Design and methods*. Thousand Oaks, California: Sage Publications, Inc.

Zeichner, K. (2009). Rethinking the connections between campus courses and field experiences in college- and university-based teacher education. *Journal of Teacher Education*, *61*(1-2), 89–99.

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