Science Education at the Crossroads

SEPTEMBER 25-27, 2014 ☽ ✹ ☾ PORTLAND, OREGON

2014 Conference Proceedings

The best journeys are those that begin with a clear itinerary. In your hands you hold such a guide for the 2014 Crossroads Conference. This document is akin to an atlas to orient you to the professional learning you will engage in from September 25–27 in Portland, Oregon. Within the pages you will find the conference schedule, a map of our meeting spaces, along with the Vexations and Ventures from all of your co-presenters. The combination of times, places and people suggest how this — the EIGHTH iteration of **Science Education at the Crossroads** — will proceed. Thus the Proceedings offers insights about what will occur acting as a reference to one day look back upon.

Experience tells us that the Proceedings is a topographical map that provides a sense of geography without necessarily defining exactly what paths each of us will follow or exactly what we will learn along the way. Each Crossroads is unique unto itself because of the various people who attend and the venues in which we gather. Within the same sessions, each person will have his or her own nuanced experience. And although the group will spend much of its time in Portland together – talking, listening, eating, and even crafting – at its conclusion, each Crossroads attendee will have traveled a distinct path and reached a different destination. We embrace this a virtue of Crossroads because each attendee benefits in ways that are responsive to individual challenges and ambitions. Similarly, these pictures from a recent backpacking journey reveal the perspectives of three individuals:



As is true with many treks, a persistent challenge surrounding **Science Education at the Crossroads** has been the inability to adequately describe the event to outsiders. As inclusive as we strive to be, there remains a mystique that confounds us. Past attendees can probably attest to the challenge of explaining Crossroads and so we have decided to address this problem using images rather than mere words. We are optimistic that documenting key components of Crossroads will not alter your participation in the conference. Our videographer, **Ron Proctor**, will be unobtrusive as he gathers footage that will allow us to better understand and explain Crossroads. Under the best of circumstances, the video, audio, and associated narratives will support others who wish to adapt Crossroads to other professional learning situations. Assisting us in the conceptualization and implementation will be **Julianne Wenner,** who will be pivotal to mentoring Facilitators while providing valued and fresh perspectives.

And so it begins – another Crossroads full of professional learning promise! Thank you, because your presence enriches the journey for all of us.

John Settlage & Adam Johnston

CONFERENCE SCHEDULE

Thursday, 25 Sept 2014

2:00 – 7:00 pm	**Arrival**	**Heathman Hotel,** Portland, Oregon	1001 SW Broadway @ Salmon
7:00 – 8:00 pm	**We Begin**	***Reception and Welcome*** *Adam Johnston & John Settlage* ***First Incubator:*** Juanita Jo Matkins and Jackie McDonnough – & Jenna Carlson, *Facilitator*	Symphony/Opus and Broadway *Mezzanine Level*
8:00 – 9:00 pm	**Orientation**		
after hours	**Networking**		

Friday, 26 Sept 2014

8:30 – 9:00 am	**Welcome**	**Re-Welcome & A Special Fresh Introduction**	
9:00 – 10:00 am	**Keynote Address**	***Professional Learning: Journeys with a Plan B*** Adam Johnston & John Settlage	Fremont Morrison
10:00 – 10:30 am	**Break**		
10:30 – 11:45 am	**Incubator A**	Bryan Brown & Bhaskar Upadhyay (w/ Jess)	Sellwood
		Meena Balgopal & Brian Fortney (w/ Alicia)	St. Johns
		Michelle Brown & Mark Enfield (w/ Clif)	Symphony
		Terri Patchen & Francis Broadway (w/ Tyler)	Opus
12:00 – 1:00 pm	**Lunch**		
1:15 – 2:30 pm	**Incubator B**	Adam Johnston & John Settlage (w/ Jenna)	St. Johns
		Heidi Carlone & JT Taylor (w/ Alicia)	Symphony
		Noemi Waight & Rachel Wilson (w/ Clif)	Opus
		Cory Buxton & Max Longhurst (w/ Tyler)	Sellwood
2:30 – 3:00 pm	**Break**		
3:00 – 4:15 pm	**Incubator C**	Karen Lionberger & Scott McDonald (w/ Jess)	Symphony
		Andy Cavagnetto & Meredith Kier (w/ Jenna)	Opus
		Ron Gray & Beth Raynor (w/ Alicia)	Sellwood
		Ed Lyon & Carla Zembal-Saul (w/ Tyler)	St. Johns

Friday, 26 Sept 2014 (continued)

4:15 – 7:30 pm	**Free Choice**	Strolling, relaxing, shopping, dining, & talking …	
7:30 – 8:00 pm	**Treats**	**Dessert Reception**	Fremont Morrison
8:00 – 9:00 pm	**Guest Speaker**	**Heather Mars,** *Science Education Celebrity*	
after hours	**Chatting**	Keep the conversations going	

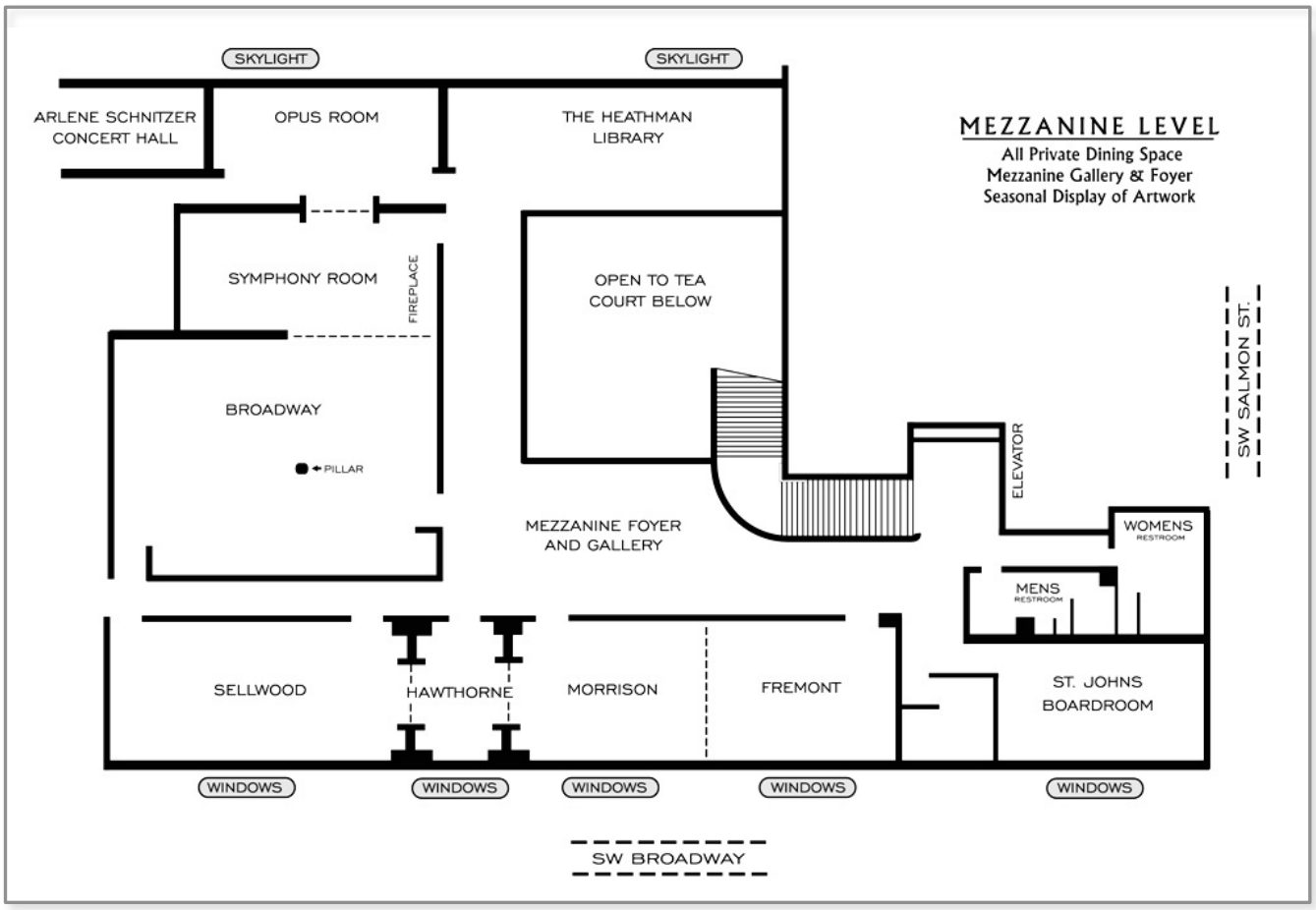
Saturday, 27 Sept 2014

8:45 – 10:00 am	**Incubator D**	Meg Pichette & David McCullough (w/ Jess)	Opus
		Elizabeth Coleman & Erin Furtak (w/ Jenna)	Sellwood
		Angela Johnson & Megan Leider (w/ Clif)	St. Johns
		Steve Fletcher & Ann House (w/ Tyler)	Symphony
10:00 – 10:30 am	**Break**		
10:30 – 11:45 am	**Incubator E**	Rachael Gabriel & Jessica Thompson (w/ Jenna)	Sellwood
		Doug Larkin & Lara Smetana (w/ Cliff)	St. Johns
		Todd Campbell & Holly Godsey (w/ Jess)	Symphony
		Michael Giamellaro & Savitha Moorthy (w/ Alicia)	Opus
noon – 1:00 pm	**Lunch**		
1:0 – 2:00 pm	**Break**		
2:00 – 3:30 pm	**Town Hall**		Fremont Morrison
After	**Ventures**	**City Tours!**	

Budgetary Note

Science Education at the Crossroads is supported entirely by registration fees – along with some loose change John and Adam found lying around that their respective administrators allowed to apply to Crossroads. As the Proceedings goes to press, we project registration revenue totaling $6870. Our budget for food/space is $7000. The Proceedings and their mailing, as well as our keynote speaker, have been paid for via funds from John; additional supplies and remaining food/space costs are covered by funds from Adam. We've each also contributed to videography expenses and travel. This is all to let you know that your registration fees are being used immediately on this conference, in their entirety. There is nothing left in the money bucket once the meeting has concluded. Frankly, we wonder why more conferences don't operate this way.

Heathman Hotel
Floor Plan



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 2014 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, babysitters, etc. Each deserves hearts, stars, and/or glitter next to their name.

Jenna Carlson	**Clif Marr**	**Alicia McDyre**	**Tyler St. Clair**	**Jess Stephenson**

Incubator Forum 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, Portland, OR, September 25–27 [Available online at www.sciedxroads.org/proceedings2014.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). Portland, OR. [Available online at www.sciedxroads.org/proceedings2014.html].

Measuring the Meming of STEM at One Middle School

Meena Balgopal
Colorado State University

OUR INTERACTIONS WITH OTHERS HELP DEFINE OUR COLLECTIVE IDEAS as well as what we value at a particular time and place. Our interactions involve communicating with one another through multiple modes and symbols. What is amazing about human language is that it is a flexible mode that both adapts and persists in multiple contexts. Some words and phrases remain in our lexicon for generations while others are either lost or remain with modified meaning. It is through the pragmatic lens of communication studies that I enjoy scientifically making meaning of how others make meaning of science. However, studying how people make meaning of language can be challenging. My current study centers on explicating how stakeholders at one STEM middle school interpret the term STEM. I believe that this acronym has acquired its own meaning beyond the separate words that it originally was meant to capture: science, technology, engineering, and mathematics. It's a term that is in fashion amongst those talking about work force readiness, school achievement, diversity and equity, and science literacy. Within each context people use the term in slightly different ways as they try to make sense of whether they share the same meaning. In short, I believe "STEM" is a *meme*.

Dawkins (1976) coined the term, meme, in his well-read book, *The Selfish Gene*, in which he argued that genes are the units of natural selection. Although I argue that individuals are the units of natural selection, I believe that Dawkins' comparison of genes to memes (cultural units) of heredity is worth examining. Memes in the form of words, phrases, fads, and icons travel through populations as genes travel through individuals across generations. As meme variants emerge, some persist under certain selective pressures while others go extinct. If a meme has value and utility for those who use it, we might predict that it is more likely to persist. If not, it may morph so it meets people's needs. And if it no longer is needed to convey meaning, it may rarely surface in conversations, and if it is lost, there is little impact. As the symbolic interaction theorist, Mead (1962), argued, it is not the symbol itself that is important, rather the interpretation of the symbol that matters.

Although I find the STEM meme ideal for studying meaning making, I am vexed with practical and methodological issues. This is a term that is used quite frequently in a local school district in which I collaboratively conduct research with teachers and administrators. At one particular "STEM" middle school, my university colleague (Laura Sample McMeeking) and school colleagues (an administrator, John Howe, and a technology teacher, Tracey Winey) and I were able to collect survey data (consisting of two open-response questions: *What is STEM? How does STEM affect your life?*) from over 1,000 participants (in order of number of participants: 6th-8th grade students, 6th-8th grade teachers, parents of 6th-8th grade students, and administrators at the middle school). Our findings were very interesting and supported our prediction that each stakeholder group held nuanced meanings of the acronym, STEM. We were all equally intrigued and realized that our exploratory study must go further if we are to really unravel how this meme propagates through a school environment. Ultimately, we want to know if STEM is a construct that is useful for improving science learning and participation.

Memetic theory informs many studies, but most of these are in the disciplines of marketing, computer science, and technical journalism. The majority of studies use computer blogs and newsprint as data sources to conduct content and/or discourse analysis. Our research context is limited in comparison. The students use computers regularly at this school; however, most of their interactions with teachers, parents, and administrators involve face-to-face contact. In spite of having very close research relationships with the administrative staff at the school, teachers are most likely to participate in data collection (encourage students to complete surveys or submit work), if they see the immediate value and connection to their own practice as educators. My vexations are derived from the following questions:

1. How can we frame the study so all stakeholders appreciate the end goals?
2. How do we account for system complexity (students moving through systems while teachers stay there) not necessarily described in other studies?
3. Is the meme completely dependent on context (does STEM mean the same thing in/out of school for students), even when collecting data from the same individual?

Meena Balgopal
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OUR RESEARCH TEAM BELIEVES THAT WE CAN EACH GROW PROFESSIONALLY by learning from one another, so we decided to resolve the aforementioned vexations as a team. Together, we are exploring how to resolve concerns by addressing data collection and related concerns (time and type). Because memes propagate through populations, it is interesting to determine the frequency distribution of various memes at different time points. These data will allow us to paint a better picture of how and when new meme variants emerge and which ones are persisting. What makes our study context interesting is that we have different stakeholder groups (administrators, teachers, parents, students) who communicate with one another and can influence the persistence or loss of a meme variant. However, if we continually collect the same type of data (survey) too often, we anticipate student participant fatigue (and less robust responses describing what STEM means to them) and less teacher buy-in.

As a team we decided to focus on students' evolving ideas of STEM as a first step, rather than the propagation from stakeholder group to stakeholder group, primarily because this was the interest of our research partners and other stakeholders (i.e., parents and teachers) at the middle school. Focusing on students' ideas over time will help us understand how the meme changes within one group over time without the complication of understanding how the inter-group communication may change lead to these changes. Because we are also interested in why the meme changes over time, focusing on students could lead us to another vexation not mentioned previously. The second solution to our methodological concerns is to collect types of data other than open-ended survey responses. Although we plan on administering a student survey, twice in the upcoming school year—early fall and late spring, we plan to interview randomly assigned focus groups. However, due to the tentative stability of memes, we worry that students may not commit to a meaning of STEM when sitting with peers, who may use the term differently. Hence, we'd like to collect other formalized forms of data. Herein lays the other dilemma—convincing the teachers at the school to help us collect data that are still relevant for their curricular and learning objectives. Connected to this dilemma is that we are not sure what "rubric" to use to ensure that we are still measuring the same meme. If memes change, how can we truly track the meme with which we are interested in following?

We are exploring the possibility of asking all teachers to ask their students to develop the same type of assignment that teachers can use to assess student and from which we can extrapolate what STEM means to students. For example, two years ago all students at the school had to complete a "Grand Challenge" project that included an authentic inquiry activity designed and implemented by pairs of students over a 4-month period that allowed them to answer the broad question of "how can I make the world a better place?" Students wrote reports and gave presentations. We are exploring whether a similar project could be assigned across grade levels that included a common output: an infographic. These would be electronically submitted, tied to the content of the specific grade level and course, and allow for individual expression. Our team is excited about exploring this possible data source for two reasons. First, we would like to include the middle school teachers at our research site in helping design the infographic assessment, as we not only view them as experts in teaching but collaborators in our research. Including these teachers aligns very well with my history as a science education researcher, where my work heavily involves collaboration with teachers, researchers, and students researchers all as part of a university-school district professional learning community. Second, this method of assessment not only enables us to interpret students' STEM meanings, it allows teachers to document their assessment strategies, which is now essential for teacher promotion in our state. Although, these ventures seem appealing, we are currently struggling with how to implement them. We have rejected the idea of presenting students and teachers with an infographic that we have prepared because it may be assuming that we have understandings of STEM that are not shared by our stakeholders. Hence, we'd ideally like to select more open-ended forms of assessments. We invite feedback on the methodological dilemmas that we have identified. How do we include stakeholder voices and ideas in developing assignments and artifacts that will be assessed for different reasons and still be inclusive of teachers' ideas about how they influence their students' perceptions of STEM? Furthermore, does it make sense to ask other stakeholders (administrators, teachers, and parents) to generate an infographic assessment, which we would use to compare to those generated by students? And does an instrument or assessment exist that can capture different stakeholder perceptions of STEM as it morphs?

Get Them While They're Young: Capitalism as the Science Curriculum

Francis S. Broadway
The University of Akron

HOW DOES STEM EDUCATION LOOK POLITICALLY, if I dare express the political (the law) through religion? The political hegemonic heteronormative binary in religious terms is capitalism versus democracy. Capitalism: "Servants, be obedient to them that are your masters according to the flesh, with fear and trembling, in singleness of your heart, as unto Christ" (Ephesians 6:5, KJV). Democracy: "Therefore all things whatsoever ye would that men should do to you, do ye even so to them: for this is the law and the prophets" (Matthew 7:12, KJV). How do I look at STEM education if Ancient Greece, the epitome of democracy, had a slave class? Or the Roman Empire, the quintessence of a republic, which also had a slave class? And now the United States that had "slavery provisions in the Constitution" (Bell, 1992, p. 2–3)? How does STEM teaching make palatable the democratic content manifested in the Next Generation Science Standards (NGSS Lead States, 2013) and embody capitalism, institutionalized as covert master/slave arrangements?

Capitalism is a social, economic and a political system when melded creates a culture elucidated by Ayn Rand: "Capitalism is a social system based on the recognition of individual rights, including property rights, in which all property is privately owned" (Rand, 1967, p. +6) and posits "[p]roperty rights and the right of free trade are man's only 'economic rights'" (Rand, 1964, p. 67). Individuals "have absolutely no ethical obligation to other human beings" (Eckman, 2011 June 18) as the individual is "a heroic being, with his own happiness as the moral purpose of his life, with productive achievement as his noblest activity, and reason as his only absolute" (Rand, 1957, p. 1170–1171). Hence: "Capitalism and altruism are incompatible. They are philosophical opposites; they cannot co-exist in the same man or in the same society" (Rand, 1967, p. 195).

For a definition of democracy, I default to George Counts writing in reaction to the failure of capitalism, the Great Depression, and penned the United States as "parasitic capitalists living on the blood of the toiler and determined to crush at all costs the "first workers' republic in history" (Counts, 1946, p. 321).

> *A society fashioned in harmony with the American democratic tradition would combat all forces tending to produce social distinctions and classes; repress every form of privilege and economic parasitism; manifest a tender regard for the weak; the ignorant, and the unfortunate; place the heavier and more onerous social burdens on the backs of the strong; glory in every triumph of man in his timeless urge to express himself and to make the world more habitable; exalt human labor of hand and brain as the creator of all wealth and culture; provide adequate material and spiritual rewards for every kind of socially useful work; strive for genuine equality of opportunity among all races, sects, and occupations; regard as paramount the abiding interest of the great masses of the people; direct the powers of government to the elevation and the refinement of the life of the common man; transform or destroy all conventions, institutions, and special groups inimical to the underlying principles of democracy; and finally be prepared as a last resort, in either the defense or the realization of this purpose, to follow the method of revolution. (Counts, 1932/1978, p. 38)*

Thus, my vexation is the (re)presentation of the STEM classroom as a overtly capitalistic classroom whereby the ills of being African American can be minimized if African Americans were taught to be free – the paradox for schools: ***To create individuals who can successfully live in a capitalist world or to create individuals who are capitalist.*** The capitalist STEM classroom encourages success measured as eliminating the achievement gap or African Americans being a model minority, non-black (Wu, 2013) albeit there is no way to become white, where there are no Blacks – "Heads bowed, arms now linked by slender chains, black people left the new world as their forebears had arrived" (Bell, 1992, p. 194)? The success for African Americans lie in the individualistic, greedy, selfish, entrepreneurial, business, free market classroom. Success is not in nurturing the developing moral child, but in encouraging a child's achievement.

IF "CURRICULUM IS A STATEMENT OF WHAT THE OLDER GENERATION VALUES" (Sizer, 1999, p. 161) and "the implicit curriculum of the school can teach a host of intellectual and social virtues: punctuality, a willingness to work hard on tasks that are not immediately enjoyable, and the ability to defer immediate

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gratification in order to work for distant goals" (Eisner, 1979, p. 81), then capitalism must be the explicit curriculum of science classrooms. No longer can teachers seek to enable African American students to be democratically successful. The curriculum and content of science to be covered, to be known, and to be able to be done is successful if and only if African American students become capitalist. Abraham Lincoln (1858/2004) who spoke "I am not, nor ever have been, in favor of bringing about in any way the social and political equality of the white and black races" (n.p.), championed, in a speech in New Haven, CT, capitalism– the acquisition of property (economic equality) as a position "where the negro should [not] be denied every thing" (n.p.):

> *I take it that it is best for all to leave each man free to acquire property as fast as he can. Some will get wealthy. I don't believe in a law to prevent a man from getting rich; it would do more harm than good. So while we do not propose any war upon capital, we do wish to allow the humblest man an equal chance to get rich with everybody else…. I want every man to have the chance — and I believe a black man is entitled to it — in which he can better his condition — when he may look forward and hope to be a hired laborer this year and the next, work for himself afterward, and finally to hire men to work for him! That is the true system (Lincoln, 1860/2012).*

as the only attribute for a race which need to be removed from the United States. Thus, it has never been acceptable that students [sic] exist, live, and survive *in* a capitalist world writ by Lincoln as the "black man as hired laborer." African Americans need *to be* capitalists – Lincoln's "black man" who is "to hire men to work for him", as were the framers of the Constitution of the United States (Bell, 1987).

Furthermore, science must be taught and learned though modeling and rewarding obedience, compliance and complicacy. Acknowledging that the science of science's heroes, be it individuals such as Alfred Nobel and Fritz Huber or nameless projects such as the Manhattan Project, are capitalistic triumphs since these sciences adopted "individual affiliation in the sphere of [the] economic … [capitalism's] deification of the principle of selfishness, its exaltation of the profit motive, its reliance upon the forces of competition, and its placing of property above human rights" (Counts, 1932/1978, p. 46–47). Science teacher preparation must abandon the platitudes of "[i]t is of crucial importance to build a democratic project – including schools – wherein ordinary men, women, and children find it safe to be altruistic, so that they can act in a way that serves the public good and their own" (Brosio, 1994, p. xix). If I embrace capitalism, then I will understand what is expected of me as measured by Council for the Accreditation of Educator Preparation accreditation standards and science teacher candidates must teach science guided by oxymoronic platitudinous ideological pronouncements such as "No Child Left Behind" or "Race to the Top" or the paradoxical Common Core-based science standards. In other words, in order to facilitate the "moral, physical, and educational uplift of American youth" (http://www.cadetcommand.army.mil/jrotc-history.aspx) as well as the "Negro race" (Du Bois, 1903/1996; 1948/1996), I must be a capitalist.

I ask if I am writing a parody. Knowing the meanings of words are cryptic and ambiguous (Rosenblatt, 1956), I could not be asking myself to be virtuously selfish (Rand, 1964) by creating a law of the jungle and the eugenics of the bell curve (Herrnstein & Murray, 2010) classroom and to champion and to support students who are blindly and uncritically obedient, complacent, and compliant to the wishes, desires, and authority of their selves as hegemonic oppressors? I mock myself when I masquerade as a democratic, "an ethical ideal [that] calls men and women to build communities in which the necessary opportunities and resources are available for every individual to realize fully his or her particular capacities and powers through participation in political, social, and cultural life" (Westbrook, 1991, p. xv). I gaze at myself and finding one who has admitted that institutions of higher education are businesses albeit with a laissez-faire capitalistic ontology and with the moral purpose of pursuing its own happiness. I would feel "vexatious" until I become a capitalist, or at the least a disciple (Wilde, 1893/2003) of capitalism. I am serious. I will find peace, joy and happiness when I become the oppressor by shedding the shackles of self-imprisonment and begin to live without being black, a Negro, an African American in a post-racial colorblind society and guarantee that my African Americans become oppressors (job creators) rather than the oppressed (job seekers) (Friere, 1970/2000).

An Alternative Approach to Dissemination

Bryan Brown
Stanford University

INTELLECTUAL LIFE IS FULL OF CONTRADICTIONS. One of the primary challenges associated with being a modern academic is to add to the intellectual foundations by merging new ideas with ideas uniformly recognized as critical to explaining success in education. In one breath, we look forward in an attempt to offer new ways to solve common problems, while simultaneously relying on old ideas to get us there. Imagine the contemporary medical researcher needing to reference the work of Jonas Salk in a new study on capsid proteins. The logic is misplaced and reflects a fundamental paradox in contemporary science education.

This mind-boggling contradiction is most notably recognizable in our process of disseminating research. As scholars, we use a network of peers to determine the quality of our scholarship. This peer-reviewed system is designed to promote rigor, intellectual vitality, and accuracy. This intellectual endeavor literally emerged in response to Sir Isaac Newton's attempts to publish his treatise on Optics in 1704. His conflicts with Robert Hooke and the National Society lead to the development of the system we use today. Where this system finds its strength is in its ability to bring thinkers together to reflect upon and validate new research. However, does this system effectively disseminate information to the people who can use the information in meaningful ways?

In Newton's time, the book was CNN, Twitter, and The New York Times all rolled in one. Texts served as the primary medium for building and disseminating knowledge. In 2014, knowledge is shared instantly via Facebook, YouTube, Television, Instagram, Twitter, SnapChat, and numerous other multimedia venues. So, the question emerges, why do we continue to rely on print journals as our primary dissemination mechanism of new information about science education? Failing to skillfully use multimedia venues ensures the voice of the science education community is fundamentally silenced – and allows mainstream media and aggressive self-promoters to determine what new research and approaches to teaching are deemed innovative (e.g. Khan Academy).

The nature of my vexation involves a deeply seeded motivation to change the way science education scholars disseminate our research. I am vexed at our continuous reliance on peer-reviewed journals as our evaluation and dissemination mechanism. In moving forward in this digital age, I would like to explore the development of an alternative mode of public communication of science education that uses journals for validation purposes, but takes an aggressive approach to using multimedia to disseminate research results to the public at large.

VENTURE

Alter the contemporary dissemination model. It is not enough to merely critique our current model of intellectual dissemination in science education. Our promotion, evaluation, and tenure processes all rely on this entrenched system. Instead, we must consider how to use the current system in a way that adopts its strengths, while pushing past the limits of its current lack of overall effectiveness. Ultimately, I am proposing the adoption and execution of an alternative means of academic dissemination that intertwines historical models of review with modern approaches to sharing information.

Recognize dual responsibilities. To adopt an alternative model, we must first recognize our dual responsibilities as science education researchers. We are not Sociologists. We must do more that merely explain the problems of education or describe what works. Unlike many disciplines, our fundamental responsibility is to engage in research that does a variety of things. This includes describing how to train teachers, predicting what instructional practices work best, explaining how to best structure informal science environments, explaining what curricular models work best, explaining how race identity and culture matter, and proving how science learning works. We must also train people to use this knowledge in meaningful ways. As a result, we maintain the dual responsibility to produce new knowledge and deliver it to the community who can use is. Our current model only allows us to develop new knowledge, but fails miserably to provide knowledge to teachers, schools, and families who could use the information in meaningful ways. Therefore, I propose developing an alternative model of validation and dissemination that seeks to use the old journal system with a more efficient, dissemination and communication model.

Create synergistic means to share information in a digital age. To do this, I am proposing the building of a dissemination system that is based on including 4 primary mechanisms. These mechanisms include: (1) creating a dissemination network, (2) generating sets and subsets of professionals with common perspective, (3) building teacher networks, and (4) using a multimodal researcher distribution system.

Create dissemination networks. The first stage of this process is to create a network of intellectuals and practitioners who literally serve as nodes of communication. Figure 1 provides a representation of what this network may look like. If common-minded scholars were to share their professional networks, meaningful information could be quickly disseminated to people who may need the information in ways that reflect our 21st century capabilities. Using Figure 1 as an example, the individual in Network 1 could disseminate a white paper about a recent discovery

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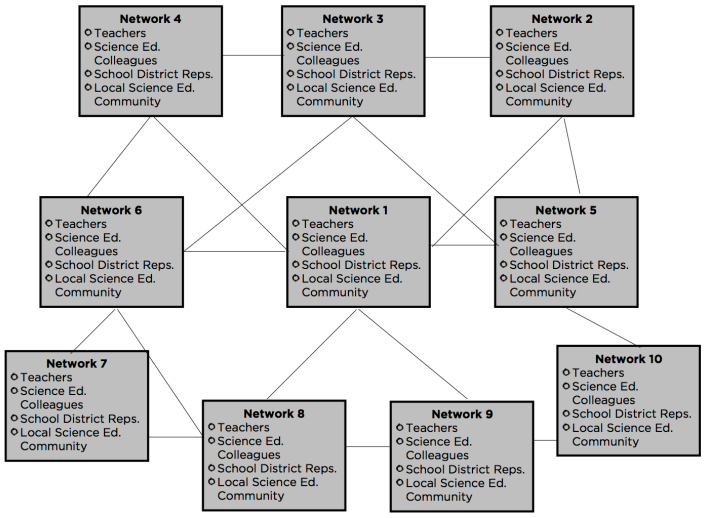
about using formative assessment for teaching. That document could be delivered directly to the inboxes of Teachers, Science Education Researchers, School District Representatives, and Local Science Education Community members instantaneously. Sharing between networks would allow information to be quickly redirected to those who need it. Building this type of network could dramatically increase the type of dissemination effect researcher could have.

Researchers of Common Perspective. A second task is to build a network of scholars and thinkers who share a common perspective. Assuming the network shown in Figure 1 is a network of urban science educators, the knowledge could be shared among scholars, teachers, and leaders who share a common goal of improving urban education. These networking communities can serve dynamic tasks of coalescing common thinkers and providing information that is more accessible to the people who need that information.

Teacher Networks. A third task is building a sub-network that is directly tied to a team of teachers. The connection between research and teachers is perhaps our weakest link within our industry. Although our primary research goal is to effect schools and informal science learning environments, our direct communications are very thin. As such, building teacher networks that are directly accessed through these dissemination links would allow research to arrive in the hands of teachers without the several layers of gatekeepers that currently exist.

Figure 1. Sample of a dissemination network



Use Appropriate Media. The final challenge is changing the way we describe about our research. First, I am not arguing we should avoid write traditional manuscripts. Rather, I am suggesting we write and record multiple versions of our current research. This multimodal representational approach would include our producing the following:

i. **White Papers**

We should write shorter 1-2 page papers that present our data in an empirical fashion that is academic but brief. These should be formatted in a professional manner and made publically available to all. As people Google search topics, these should be immediately available.

ii. **Video Blogs**

We should produce brief 1-4 minute documentaries explaining our research and its meaning. These brief vignettes can be efficient and powerful ways to share information.

iii. **Video Exemplars**

This is slightly different than a video blog in that this is a representation of the actual practice being demonstrated in schools and informal learning environments. Showing people what works and how it works could have a powerful effect.

iv. **Multiple Audience Writings**

Similar to what is described above, the basics of this idea are to write our research and present it in multiple forms. Busy people read information that is written with them in mind. As a result, science teachers, and researchers would read Blogs and Newspaper articles dedicated to helping them if we merely wrote them. As a result, I would argue that people in these networks write Blogs, Full Research Manuscripts, White Papers, Press Releases, and Newspaper articles.

Overall, I venture to establish such a network to alter how we can improve the global impact and application of science education research.

Applying the Crossroads Format to a Mentoring Program: Instructional Coach + Vexation/Venture = ?

Michelle Brown, *Brooklyn Prospect Charter School*

Science Education at the Crossroads has helped me grow as a teacher more than any other conference or workshop. I am especially interested in how this conference differed from professional development (PD) opportunities for classroom teachers. I look to the Crossroads conferences as a model for how to make PD more meaningful for teachers and have tried to incorporate aspects of the conferences into the few PD workshops I have led. My vexation and venture is about how to improve the teaching practices and community at my school in my new role as a teacher coach.

Background. For the past two years I have taught 9th grade Earth Science at Brooklyn Prospect Charter School (BPCS), in Brooklyn, NY. My school is in its 5th year. This year we have two campuses: one that holds grades 6–10 and a new campus that initiated a kindergarten program. Every year BPCS will add a new grade until it teaches grades K–12. We have a diverse group of students, a fairly diverse faculty (both in experience and ethnicity), and our administration ("operations") is divided between the two campuses. We are an International Baccalaureate school with certification for the middle years program (grades 6-10), with hopes of becoming certified for the diploma years program (grades 11–12) next year. Our test scores are admirable and our leadership team pushes us to be innovative. Most of our faculty is young and hard working—it is not uncommon to see teachers leaving after 7 p.m. or sending emails late at night on a weekday or during the weekend.

We have many systems and programs at the school, some of which are quite innovative. For example, we used an 8-hour PD day as "innovation day" where we worked with colleagues to add a novel practice, program or product to our school. We have early-release days on Wednesday and Thursday, and spend 1 to 2 hours after school in grade-level, department or school-wide meetings. This year, we worked in collegial inquiry groups once a month conducting action research as part of our PD.

Although there are many positives about our school, we experience "growing pains" as the high school learns how to address new issues and our school's old systems break down when more students and teachers are added. Although some new teachers thrive in this environment, many struggle as they face many new programs and expectations. Our tightly packed days make it difficult to check-in with new teachers or colleagues to discuss ideas not addressed in our meetings. Lastly, although our school flourishes in the thoughtful ways it fosters creativity and diversity, I feel as though we struggle to give new teachers a more nuts-and-bolts sense about school operations and teaching practices in general.

I am now at my own crossroads. After spending 8 years as a full-time science teacher, I will move into a part-time job as an instructional coach next year as I raise my daughter. I will work 15 hours a week with Math and Science teachers. I will observe all the teachers, confer with department heads, and have a focused approach to help our struggling and/or new math and science teachers with their practice. I have considered a future in teacher education and see my new role as an opportunity to help struggling teachers with their practice, as well as how to adapt to BPCS.

MY SCHOOL HAS THE POTENTIAL TO CREATE STRONG, INNOVATIVE SCIENCE and math departments that can push the boundaries of education. BPCS administration and teachers welcome change, reflection and improvement. The only problem is we are all too overwhelmed! Although we have a strong community as an entire school (teachers, parents, students, staff), we don't have enough time to become a community as a department.

Another vexation is that we do not successfully mentor new teachers. The department chairs observe and give feedback to these teachers (and all teachers in their department), but there is not a dedicated, non-administrative mentor to whom teachers can reach out daily. The departmental chairs do a phenomenal job helping new teachers. However, as their supervisors, it is difficult to foster relationships that allow teachers to openly reflect on weaknesses in their teaching. New teachers need to learn a lot in their first year, and at BPCS they experience added pressures and expectations due to the intense level of involvement at our school. For example, all teachers are expected to lead one club, tutor three times a week and have an advisory with its own curriculum. The stress put on new and returning teachers causes some to leave.

Michelle Brown, Brooklyn Prospect Charter School

I am excited by these vexations, because I will have a chance to help solve these problems as an instructional coach. My fundamental vexations behind these concerns are: 1) How do I best help teachers develop and innovate their practices in an environment that can be debilitating? and 2) How do I cultivate a community where teachers help each other grow in their practice despite a culture that puts most teachers in survival mode?

IF THERE IS ONE THING I HAVE LEARNED from my previous Crossroads conferences, it is to start small. I have a tendency to want to make big changes and to see them happen quickly. Also, I need to remember that I am no longer in direct control of student achievement and the strategies that worked best for me when I taught may not be the best for other teachers. My job as a coach is to help teachers improve on their practice. (I use the word "improve" to mean that the teachers shift their practice or thinking in a way that increases student achievement.) I believe this is most effective when the ideas originate from the teachers, not from me. I intend to do the following within my role as an instructional coach:

- Get to know every teacher and help him/her identify areas for improvement, create interventions and reflect on them in a cycle through weekly observations.
- Build community within the math/science departments from the beginning of the year, helping new teachers feel comfortable within the department earlier (e.g., happy hour).
- Check in with new teachers routinely to ensure they understand the systems and expectations of the school and help them prioritize requirements. I will advocate for new teachers, especially those who are overwhelmed, and try to limit requirements that are not a priority.
- Show videos of my own teaching and ask teachers to identify areas of strength and weakness. I will show video clips where I struggle, as well as video clips that show successful strategies at work. I believe this will allow teachers to feel more vulnerable as they get observed and reflect on their own practice.
- Film teachers and send them the video so that they can be reflective of their practice. Although I will not require teachers to watch the films, if a teacher is feeling very frustrated, we can use the clips as a resource to discuss problems and solutions.
- Help teachers identify their own vexations associated with their practices. For newer teachers or those who struggle with being reflective, we may refer to the video footage I collect to guide them to the most meaningful aspects of their teaching. Teachers will brainstorm interventions and I will focus on these aspects during observations.

Although the objectives above are important and will be useful at helping math and science teachers, they do not have the spirit of a true venture. I would like to foster something that goes beyond typical coaching strategies and explores how building a community and using innovative tools such as the vexation/venture format can affect transformation in teachers. My fear is that teachers will be so caught up trying to write curriculum, grade papers and respond to emails that they will not have time to improve on their practice. Perhaps there is a way to make room for reflection without adding to the already sizable teacher workload. Teachers could share out their vexations and ventures through a happy hour every other week, or use an online format to give feedback to their colleagues' concerns. I am open to input concerning how to foster change in the community of math/science teachers with a finite amount of time and energy. The question is: how do I do this?

Talking Back to the "Ideal" of Fidelity of Implementation

Cory Buxton
University of Georgia

Vexation – The problem with believing in one-size-fits-all solutions to professional learning

THE CALL FOR ENHANCED SCIENCE TEACHER PROFESSIONAL DEVELOPMENT is not new (National Commission of Science and Mathematics Teaching for the 21st Century, 2000) but has gained renewed urgency as a result of the latest round of science education reforms (National Research Council, 2011; 2013). This policy push for improved science teacher preparation has become increasingly complex as a result of four interrelated factors: a) the growing cultural and linguistic diversity of the U.S. student population; b) the persistence of testing gaps across demographic subgroups coupled with increased test-driven accountability demands for all students and teachers following the federal Race To The Top (RT3) initiatives; c) an increase in both the cognitive and linguistic demands inherent in the latest science reform documents, A Framework for K-12 Science Education and the Next Generation Science Standards; and (d) evolving personal and social reasons why all students need access to challenging science learning, such as to make informed decisions about technologically driven problems and solutions, for career opportunities in the current global economy, and for the personal satisfaction that comes from understanding the natural and engineered processes that shape the world around us.

We developed the Language-Rich Inquiry Science with English Language Learners (LISELL) project in response to this multifaceted challenge of supporting science teachers in meeting the evolving science learning needs of a changing student body. We were particularly interested in what it meant to do this work with teachers in the context of the new Latino/a diaspora in the Southeastern United States (Wortham, Murillo & Hamann, 2002). Our goal was to design, implement, and research a pedagogical model and a teacher professional learning framework that would explicitly support the science and language learning needs of all students, and especially the needs of Latino/a bilingual learners. We knew that working with teachers to simultaneously support the teaching of reform oriented science practices, the language of science, and an awareness of the cultural and linguistic resources that bilingual learners bring to the classroom would be complex and challenging. I have long been vexed that the organizations most likely to fund such research (NSF and US DOE/IES) wish to downplay or even disregard the implications of such complexity when it comes to designing and researching teacher professional learning.

Research studies of teacher professional development are typically framed around tracking participation and implementation in the hope of drawing causal connections. That is, we might consider that teachers participate in a professional learning project to learn what we, as researchers, want them to do to improve their teaching. And then, teachers are to implement what they learned from us, with varying degrees of fidelity, into their own classrooms. As researchers, we then evaluate how well their implementation matches our ideal. I have always been dissatisfied with this this approach, finding that it does not match either my theoretical orientation or my pedagogical approach to working with teachers.

By extension, we might also consider the shortcomings of this model as we map our own career trajectories as scholars, teacher educators and members of academic institutions. What are the idealized models of success in the academy and how well do we, can we, and should we implement them with fidelity? In short, do we believe that there are one-size-fits-all models of professional learning and development, be it for middle school science teachers, pre-service teachers, or for university faculty? While I firmly believe that the answer to this question is no, I also feel that we need a more positive framing of what we should aspire to in our professional learning trajectories. Rather than simply saying that we do not adhere to a model that looks to replicate one ideal of professional learning with fidelity of implementation, what would we wish for instead?

Venture – Taking a stand for multiplicities of enactment

FROM A FIDELITY OF IMPLEMENTATION PERSPECTIVE, classroom observations and debriefing sessions are often viewed as the key context in which researchers can best observe and evaluate how teachers enact project practices. My own theoretical orientation, however, requires care not to privilege the gaze of the observer over the perceptions of the observed. Thus, we have been attempting to give equal weight to data from our own observations and to data in which teachers articulate their own enactments, and we see this

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balance as necessary for adequately representing and interpreting teacher professional learning in our project. In our attempt to move away from a model of fidelity of implementation, we seek to move beyond classroom observations as the primary site of studying teachers' practices, instead giving equal attention to the varied components of our professional learning framework: a) our teacher institute, b) student summer academy, c) the "Steps to College through Science" bilingual family workshops, and d) teacher exploration of student writing sessions. In the LISELL project, we have come to theorize our work in terms of teacher engagement in professional learning and teacher enactment of practices from the pedagogical model with an eye toward intentionally fostering multiplicities of enactment.

For us, teacher **engagement** in professional learning differs from participation in that engagement implies agency both in choosing *which* professional learning experiences to engage in and *how* to engage with the work during the professional learning experiences. Thus, participating teachers are encouraged to attend as many and as wide a variety of the LISELL professional learning activities as they can. But we also make it clear that we view all teachers as important project participants, even if they are only rarely able to attend our professional learning or if they choose only to attend certain components of the professional learning.

Similarly, we conceptualize teacher **enactment** (as opposed to implementation) of the LISELL pedagogical model as agentic through teachers' choices about which aspects of the pedagogical model they take up in relation to what topics and with which students, as well as how they adapt the LISELL practices to best suit their perceived needs. We expect and encourage this adaptation (which we refer to as *multiplicities of enactment*) as opposed to expecting or encouraging fidelity of implementation as teachers translate professional learning into their own professional practice in their own distinct school and classroom contexts.

We are now beginning to study teacher engagement in all components of our professional learning by tracking attendance and by examining what sense teachers make of the activities they engage in, as reflected in various data collection activities within each professional learning context (e.g., a science notebook in the teacher institute, audiotaped debriefs and written reflections from examining student writing sessions, etc.). We are tracking teacher enactment of LISELL project practices through a combination of grand rounds classroom observations and the data sources from the other professional learning contexts, in which teachers discuss and justify their own enactment choices of the practices of the LISELL pedagogical model. We continually ask ourselves as a research team if we are giving sufficient weight to teachers' articulations of their own enactments, rather than privileging our own observations and interpretations. This is not to say that I believe any approach a science teacher takes when working with English learners is equally valuable in supporting student learning; I do the work I do because I believe that we can all learn to teach in more powerful ways. Rather, I want to talk back to the idea that researchers possess answers that can be unproblematically passed on to teachers to implement with fidelity and without regard to context, prior experience, personalities and a host of other factors. The research on student learning has long ago debunked the value of the banking model of teaching. Why then do we seem reluctant to let go of this model in adult professional development?

I am comfortable moving ahead with this venture in my own research. I am less comfortable speaking out about this issue with the funding agencies that support our work or with state Department of Education officials who are in the process of implementing a new teacher evaluation system that is firmly grounded in the idea that there are context-independent "best practices" for teaching that should be implemented with fidelity. I am also interested in thinking about how exploring multiplicities of enactment in our research might inform our own professional trajectories in Colleges of Education that are now being more closely monitored and evaluated by accountability systems that run parallel to those influencing K-12 schooling. Recently, I was in a professional learning session in which I was being trained in our new teacher candidate assessment system and the trainer began talking about fidelity of implementation regarding the preparation of teacher candidates. I bit my tongue because I couldn't frame a concise comment or question about my complex vexation. I'm hoping that the Crossroads community can help me conceptualize a way to apply my thinking about multiplicities of enactment developed in my research to other areas of professional learning.

Professional Learning: Sustainability and Spread

Todd Campbell
University of Connecticut

Vexing about the implementation and spread of professional learning

WHEN CONSIDERING PROFESSIONAL LEARNING, the most pressing vexation I am experiencing is grounded in both moral and pragmatic issues of sustainability and spread of professional learning.The immediate context for this vexation is an NSF DRK12 project that is approaching the final years of funding, but this vexation is also grounded in past experiences with other funded projects. This current project is focused on professional learning for science teachers supportive of inquiry-based teaching and learning with technology. Like all projects, our work has required extensive capital, both monetary and human, throughout all phases (e.g., conception, design, research, professional development) and for the most part I feel as though our project has met or exceeded intended expectations through partnerships we have developed with districts, teacher leaders, teachers and research that has emerged to demonstrate the impact of the project in terms of changes in teacher orientations, teaching practice, and teacher and student learning. However, one facet of the project that I believe is the most pressing and perplexing is related to the sustainability and spread of the professional learning initiated in this project beyond the funding period, not just to allay feelings of obligation to NSF, but more importantly as a moral obligation to the districts, teacher leaders, and teachers who have entrusted us with their time, effort, collaboration, and friendship. Therefore, this vexation is primarily concerned with (a) sustainability or mechanisms for supporting continued professional learning related to our current NSF DRK12 project and (b) spread or the use of validated design principles found supportive of professional learning in our current NSF DRK12 project to inform the development of subsequent learning in similar, as well as differing contexts.

While not originally conceived as such, much of our project's work can be described by the stages of educational design research (Mckenney & Reeves, 2012), closely related to Design Based Implementation Research (Fishman, Penuel, Allen, Cheng, & Sabelli, 2013), especially since our work has focused on developing theoretical understandings about science teaching and learning while concurrently working to transform educational practice. As a context for our project, it is grounded in exploration and analysis phases that helped identify problems of practice related to instruction and resources supportive of knowledge-centered reformed instruction. The initial exploration and analysis supported a design and construction phase whereby four curricular modules were iteratively designed through early piloting in teacher leaders' classrooms and sustained refinement in teacher participants' classrooms. Additionally, the exploration and analysis phase led to the development of a PD model grounded in the curricular modules as both PD learning anchors and instructional resources for teachers. While not a linear process as described here, the design phase led to an evaluation and reflection stage where proxies, such as student achievement and teacher practice measures, have led to our evaluative understanding of the impact of the project and reflection on the project to produce theoretical understandings (e.g. how teacher orientations shift as a result in PD (Campbell, ZuWallack, Longhurst, Shelton, & Wolf, 2014)).

I believe that the professional learning will persist beyond the project along with perhaps the continued use of the curricular modules developed. However, we have yet to develop pathways that will support (a) partner districts in systematically continuing and building on the professional learning that has occurred, (b) teacher leaders in continuing to impact peers and their profession beyond their classrooms, and (c) teacher participants to continue learning while also adopting teacher leadership stances. Such vexations emerged in large part due to the intensive efforts and resources we have dedicated to other phases of the project, which have limited the time and planning needed to ensure sustainability and spread of the project beyond the funding period. NSF funding that has supported teachers to engage in summer work and supported their release from classroom teaching for professional learning will soon end. I do not believe what we are experiencing is the exception, but rather is more likely the norm, as other projects, like others I have led, have lost traction after their funding periods. Ultimately, I believe that a weak case can be made that our work has contributed to professional learning that could spread beyond the project, but in many ways this does not seem sufficient considering more ambitious visions of sustainability and spread that seem morally warranted.

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VENTURES THAT SEEMS MOST PROMISING are framed by educational design research (Mckenney & Reeves, 2012). To some extent, our work was built on extensive collaboration among a range of actors connected to the context of our work (i.e., university science educators, district science specialists, science teacher leaders, science teachers). Most of the collaboration has focused on exploration and analysis, design and construction, and implementation, instead of on sustainability and spread of the project. In this framing, I see our funded project representing one 'meso-cycle', which is a cycle of educational design research that is comprised of several 'micro-cycles' (e.g., analysis and exploration stage, design and construction). In this context, there is a larger cycle or a 'mega-cycle' that contains multiple 'meso-cycles'. Through viewing what has occurred to date as a 'meso-cycle', it places the NSF funded cycle in the larger context of the 'mega-cycle' whereby the project is not complete, but instead is at the precipice of the next 'meso-cycle'. Through this lens, one venture entails beginning to consider and invite actors (i.e., administrators, science curriculum specialists, department chairs) connected to the current context, but with perhaps a differing perspectives and context in mind to join our collaboration. This would allow us to maintain the powerful collaborations and partnerships we have already established with current partners, but position us to take what we are learning from our current professional learning model to consider its application at a different scale and in a potentially different context. One example of this, alluded to above, might have us convening a group of administrators (e.g., building principals or superintendents) to share more about our project and to elicit the most pressing problems faced by these new partners. In this context, I can envision how what we have been learning might be resituated or re-imagined to meet the needs of a school district or building.

Similarly a different venture might have us engaging science curriculum specialists or science department chairs or mixed groups that contain administrators, science curriculum specialists, and science department chairs to consider what we have learned and how this might be helpful or need re-imagined to meet the most pressing problems or vexations of these groups. In either of these possible venture directions, these new actors/leaders would be instrumental in helping to uncover the strengths, weaknesses, opportunities, and threats, as well as the changeable and unchangeable elements in the district, school level, or department level contexts that will allow us to continue to work for transformative knowledge-center reformed instruction. Our initial ideas for beginning critical discussion with these additional actors is through an invitation to our winter workshop where we present some of the key principles and findings in our project before we engage in discussion about the most significant challenges these key actors face related to the capital our project or collaborative group might offer. This would also afford us the opportunity to give these new actors an inside 'on-the-ground' look at the current project as they are able to observe sessions of current workshops. I believe this can lead to productive reframing of our project, where I recognize the need for a dynamic project framework suitable to solving timely challenges as the next 'meso-cycle' of our educational design research is reified.

Follow-up Vexing

With respect to the proposed venture of reframing our project framework and identifying new key actors, some concerns arise. One concern related to a dynamic project framework is that key principles of the project that have led to the positive outcome of the first 'meso-cycle' might be omitted or be enacted in such a way that 'lethal mutations' occur with respect to central project principles (e.g., the framework for curriculum design might be revised so that central commitments of the current project are not maintained). Additionally, with respect to identifying new key actors, there is a concern for disrupting relationships within the current leadership team that have been cultivated for the past five years. But, while there are reasons that push against this venture, our experience to date has shown us that extended close collaboration with shared purpose leads to mutual trust and an insider's perspective of the pressures and responses to contexts that lead to timely and needed responses. Through this recognition and the systematic framing of our work within the education design research paradigm, I believe we can continually move through iterative cycles to meet these new challenges, while continuing to develop theoretical understanding regarding professional learning capable of informing a broader community.

Out-of-school Science as Resource for Improving In-school Science: Possible? Desirable?

Heidi B. Carlone
The University of North Carolina at Greensboro

FROM 2007-2012, I CONDUCTED ETHNOGRAPHIC STUDIES of "excellent" 4th and 5th grade science classrooms and followed 27 students across three to four years of school science after they experienced one year of this excellent instruction. I found that excellent and equitable science classroom cultures (1) have teachers who hold students accountable to perform themselves *scientifically* and make those norms and practices explicit and accessible for all students; (2) engage students in practices that leverage students' social identities in service of scientific understanding and engagement (i.e., being "me" and being "scientific" involve mutually supportive identity work); (3) include practices that promote knowledge as socially constructed versus individually owned; (4) minimize power differentials between "smart" and "struggling" students; and (5) connect students to established disciplinary networks so that they can thrive in a science trajectory. As Jessica Thompson and Sara Hagenah (2014) would describe it, these classrooms were equally "responsive" and "rigorous." Fourth- and fifth-grade classrooms that included the majority of these cultural elements cultivated scientific interest, competence, and affiliation across a wide range of students. In these classes, most students performed themselves as engaged, interested, and intellectual contributors.

These happy findings indicate that *good school science teaching matters*. However, the story becomes a little less hopeful as I followed these students across time. All but one small cohort of students experienced very traditional middle school science (emphasizing facts, memorization, cookbook labs once or twice per unit, bookwork, and worksheets). Overwhelmingly, students were not held accountable to performing themselves scientifically but, instead, were asked to "do school" well. Some students embraced, and many accepted, these school practices that represented significantly lower expectations of them. A couple of others (mostly students of color and/or students from working class backgrounds) resisted these practices, but at the peril of their own academic trajectories. For instance, a few students in my study who were unbelievably engaged and interested in fourth-grade science, but resisted 6th and 7th grade science, got positioned as "difficult", "behavior problems", and/or "lazy." Race, class, and gender became more salient aspects of students' identity work than did "being scientific." Most students, even those willing to do school science well, began to disaffiliate from science, saying things like, "I'm not really a sciencey person." Keep in mind all of this happened in one of the highest-performing school districts in North Carolina.

For some highly science-interested youth, the negative effects of narrow, traditional school science were countered by enriching out-of-school science experiences. For instance, Camilo, a biracial boy, noted his after-school science program as much more engaging, interesting, and "high level" than his school science class. He was completely marginalized in/by school science, but found his out-of-school science program to be a space where he "fit in" and where his passion for the natural world and natural phenomenon was celebrated and fostered. Emily, a white girl whose science interest blossomed in fourth-grade but who experienced really dismal fifth-grade science, attended a residential summer science camp and an after-school science program at a local science museum, which sustained her science interests through sixth grade.

In addition to helping these students, I think the out-of-school science could also be a resource to facilitate teachers' professional learning and improve their practices, but this claim needs further investigation and provides the impetus for my venture.

MY VENTURE IS MULTI-PRONGED. In keeping with this year's Crossroads theme of professional learning, I will focus on a plan for leveraging a summer science and engineering program for youth as a resource to facilitate teachers' learning. I'm most anxious to hear from my colleagues who have studied and/or successfully facilitated teachers' professional learning because this is a new area for me, and I need to get smart about practical and theoretical approaches.

The summer program. The target population will be diverse youth who may or may not have been successful in traditional school subjects but who have shown strong interests in and proclivities for science and/or engineering and who may not have socioeconomic resources to pursue significant out-of-school science and engineering experiences. The program will be based on design principles that emerged from my 6-year study of school science. I have outlined some of these principles in a previous Crossroads presentation [http://www.sciedxroads.org/proceedings2009.html]. These include engaging youth in science and engineering

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experiences that: (1) emphasize science and engineering as tools for social justice, altruism, and/or conservation; (2) are multi-faceted enough to capture a wide range of interests and social identities (not a narrowly constructed "mad scientist" camp); (3) foster individual and collective empowerment; (4) provide youth an opportunity to serve as community experts; (5) provide opportunities for longer-term and ongoing support; and (6) involve families in some way.

The teacher leaders. Though my team and I would oversee the curriculum development and vision for the summer program, we will invite teachers enrolled in our MEd program focused on elementary science education as well as teachers who are teaching middle school science to serve as instructors for the youth. Thus, the summer science and engineering program will be just a piece of a carefully designed, longer-term professional learning program. Ideally, the teachers will be teaching in the schools the youth participants attend, as I think this may optimize the opportunities to translate what they learn about science, science teaching, and students in the summer program to their school science contexts.

Teacher learning about what? I'm most interested in facilitating teachers' learning about: (1) rigorous science and engineering instruction (i.e., instruction that facilitates meaningful youth engagement in relevant science and engineering problems using productive disciplinary practices); (2) responsive science and engineering instruction (i.e., instruction that draws on diverse youths' strengths and proclivities, promotes affiliation, interest, and identity work for all); (3) adventurous instruction [i.e., instruction that promotes youths' identity boundary work (Carlone, et al., 2014; Tzou & Bell, 2012)]; and (4) courageous instruction (Gilbert, 2013), focused on critical science education.

Questions for my Crossroads Colleagues:

- What is the best way to facilitate teacher learning during the summer program? Is it a benefit or constraint to have them serve as teachers in the program? Or, is there some other role (teacher researchers, observers, assistants, part-time teacher) that may better facilitate their learning?
- What are mechanisms for translating the learning cultivated during the summer program to their teaching during the school year? Are there models for doing so? What would the follow-up professional development look like? Is there potential for "transfer" here? In other words, is it possible or desirable to have teachers translate their learning as instructors in this summer program to improve their school science teaching? Are there certain high-leverage practices that might promote transfer? What might those be?
- How much ownership should teachers have over the curriculum that gets enacted in the summer? Would ownership be an affordance or a constraint on their learning? Or, could we design it in a way that the teachers have more ownership over the curriculum as they participate in the program over time?

Using an Evolution Lens to Examine Classroom Community

Andy Cavagnetto
Washington State University

THE ADOPTION OF THE NEXT GENERATION SCIENCE STANDARDS (NGSS) is underway in many states including my own state of Washington. With the new standards comes hope of narrowing the scope and increasing the depth of the curriculum in K-12 public schools. Additionally, there is an increased emphasis on language as an embedded component of science instruction and along with it, greater importance placed on student abilities to think and reason (as in the construction and critique of evidence-based arguments). These new standards represent a considerable shift in the conceptualization of teaching and learning; thus ***the vision that founds the NGSS requires a dramatic cultural shift in schools*** (NRC, 2012) – one toward greater emphasis on providing opportunities for students to collectively negotiate meaning. Environments grounded in such opportunities are not easily realized. There is a clear need to better understand key aspects of the environment and the pedagogical practices that help to create the environment.

Some key aspects appear to be merging in the literature. For example, Windschitl, Thompson, Braaten, and Stroupe (2012) have built off of their work with pre-service teachers to propose a set of core practices to support student learning. Active ingredients to effective instruction for those authors include designing instruction around big ideas, eliciting student ideas to inform instruction, creating opportunities for students to discuss working conceptual models of the phenomenon to develop coherence and clarity of ideas, and pressing for evidence-based explanations. These core practices mirror those of others – most notably Hand and colleagues' work on the Science Writing Heuristic (SWH) approach (Hand, 2008). The SWH is a pedagogical approach to inquiry framed around big ideas in science. Teachers elicit students "initial ideas" and subsequently support students in numerous cycles of negotiation in individual, small group, and whole class groupings. These opportunities parallel Windschitl et al. (2012) sense-making discourse practices. Students then organize a class claim and engage in a summary writing task in which they explain the scientific phenomena. Throughout these opportunities for negotiation, students move from unsettled positions toward settled, scientifically accurate positions. Within an individual SWH activity these core practices are repeated multiple times as students engage with questions around scientific practices (e.g., how do we best test our question?) as a means to learn about a science phenomenon (Washburn & Cavagnetto, 2013).

While I agree that these practices are active ingredients to effective instruction, my own observations in the context of the SWH approach suggest that they may not fully capture the atmosphere created among our highest implementing teachers. In some classrooms I witness modeling of the core practices, yet the environment does not appear to be optimized. This was highlighted recently for me as I observed a grade six teacher who is part of an on-going professional learning project. The teacher created an appropriate space for students to engage with one another, supported students learning based on their ideas, and appropriately pressed students to explain their ideas as they worked toward the instructional target. In speaking with him after, we both agreed that it was not a strong learning experience for his students. While students were clearly engaged in the dialogue, they often talked past one another – espousing ideas without the intent to learn from one another. I had previously documented this phenomena across a series of lessons in a fifth grade classroom (Cavagnetto, Hand, & Norton-Meier, 2010). These experiences lead me to speculate that a key mediator of the core practices is a prosocial classroom atmosphere. While the previously identified core practices may be correlated with a prosocial environment, they are likely not causal.

A prosocial environment is not synonymous with a safe learning environment. An environment where students are comfortable sharing their ideas (a defining characteristic of a safe learning environment) is different from an environment where students see each other as a single entity working collectively to solve problems. In that latter, students have a shared purpose and interest, autonomy, and ownership over activities. Research in educational contexts has largely emphasized cooperation in the form of small group activities (Johnson & Johnson, 2009). Greater cooperation in small groups enhances student outcomes. What if this "group effect" could be harnessed at the classroom level? So this leads to my vexation, ***what practices support a truly collaborative or prosocial classroom***?

Using an Evolution Lens to Examine Classroom Community

Andy Cavagnetto
Washington State University

MY VENTURE IS TO USE AN EVOLUTION LENS TO EXAMINE effective classroom communities. While we commonly think of selective pressures acting on individuals, multi-level selection theory (MLS) recognizes that selective pressures ***act on all levels of a system***. In the educational system, we can think of pressures acting on individuals, groups of individuals (e.g. classrooms), and groups of groups (e.g., schools, districts, or states). It is a nested system. MLS contends that cooperation is influenced by the relative pressures across these levels. In other words, an individual is likely to act as an individual if the selective pressures are greater within a group (on individuals) than they are between groups. An example of this is when members of a crime organization provide testimony against other members in return for a reduced sentence. The converse also holds –people will cooperate, even when detrimental to themselves. This altruistic behavior occurs when the relative pressures are greater between groups than they are within groups -exemplified in the nationalism that occurred after the bombing of Pearl Harbor or the attacks on the World Trade Center. Individuals signed up for military service in direct response to such incidents.

Wilson, Ostrum, and Cox (2013) have suggested that some group pressures can be generalized across diverse contexts. They highlight the following characteristics of effective groups:

- Clear group boundaries. The identity of the group (including purpose) are clearly identified.
- Proportional Cost/Benefit ratio.
- Collective-Choice Arrangements. All group members have a voice.
- Monitoring against inequity of contributions.
- Graduated Sanctions of inappropriate actions.
- Conflict Resolution Mechanisms.
- Autonomy of groups within the larger group.
- Appropriate coordination of levels within the larger group system.

These characteristics were initially highlighted by Ostrum, whose Nobel Prize winning work examined the effective use of common pool resources in numerous societies (Ostrum, 1990). Wilson's work with social insects and later humans offered a group-selection mechanism by which these characteristics could be generalized to other groups –recognizing them as *between group* selective pressures (Wilson, 2011).

I am interested in examining the influence of these characteristics on student learning (academic motivation, critical thinking, and science knowledge). An initial observation coding scheme has been developed based on a few videos. Some of the proposed characteristics were difficult to clearly define in the videos or were ubiquitous across classrooms – those were excluded from the final coding scheme. The final coding scheme focuses on a) group boundaries and purpose, b) inclusive decision-making (this will include both collective-choice and autonomy of sub-groups), c) monitoring, and d) conflict resolution. I have a considerable number of classroom videos with differential student learning outcomes available and plan to use the coding scheme to determine the extent to which the four characteristics account for variation in student outcomes.

A second aspect of this work is the development of a student survey that assesses student perceptions of collaboration and the extent to which Wilson, Ostrum, & Cox's design principles are present in the students' classrooms. In future studies the survey will be used in conjunction with observation scheme. I believe the observation scheme and survey would be strengthened by collecting additional forms of data. At Crossroads, I am interested in hearing other ways to detect the presence or absence of the target characteristics in classrooms. Lastly, this is a new thread within my broader work on the SWH approach and adaptive pedagogy. Given the origins of the framework that guide this work, I anticipate that communicating the framework may be challenging. I am interested in hearing perspectives on the extent to which an MLS lens fits into the conversation in education. I see some clear links with constructs like power, agency, identity, and communities of practice, but am still trying to clarify areas of overlap and areas of distinction.

From Graduate Student to Faculty Member: Can Passion Survive the Tenure Process?

Elizabeth Coleman, *UNC Charlotte*

FOR ME, THIS IS A TIME OF NEW BEGINNINGS. This spring, I completed and defended my dissertation research, graduated and officially became "Dr. Coleman," and secured a tenure-track faculty position. Ok, I know this sounds like a sorry excuse for a vexation, but with this accomplishment and opportunity comes tremendous responsibility. In the coming year, I am expected to familiarize myself with an entirely new context, establish a foundation for my career, and also ensure that I use the knowledge and skills I have developed as a teacher and teacher educator to enhance the professional learning of those I encounter in my work. This is quite a tall order. And this isn't just a job. It's personal. I view teaching and researching not as purely professional acts, but personal acts that naturally embody my beliefs, values, and experiences (Coia & Taylor, 2009). These acts are also *inter*personal because I see everything I do in this new job as having the potential to enhance (or, unfortunately, also hinder) the learning and lives of others.

According to Bullough and Pinnegar (2001) "who a researcher is, is central to what the researcher does" (p. 13), and so I acknowledge that my work will always be a reflection and manifestation of my identity, not only as a teacher and researcher, but as a whole person. Because of this view, I consistently challenge myself to engage in professional actions that embody my mission as an educator, which is to facilitate others in empowering themselves through their own professional learning. I want those I work with to see their professional learning as something that has a powerful, positive impact on their own lives and surrounding communities.

So now, the vexation: I am vexed not only by how daunting this task seems, but also by the number of faculty I encounter in the realm of science education who do not seem to share this mission of facilitating the professional learning and personal growth of others. Furthermore, I am vexed that this worthy mission is not typically rewarded by the tenure system (and I suspect that this situation might contribute to the number of faculty who do not put this mission at the forefront of their work). I was sharply reminded of these vexations as I presented at professional conferences this past spring and interacted with other educational researchers who were very focused on talking about themselves and their accomplishments, rather than having a dialogue to promote the exchange of ideas.

Although I realize that conferences like this are important to attend and list on my CV (and were essential in securing me a faculty position in a competitive job market!), I couldn't help but think, "Is this act of presenting my work to this audience enhancing anyone's professional learning or personal growth?" I know I am not the first to ask this question or be vexed by the set rituals and professional expectations that come with being in the world of academia. In fact, Crossroads exists because Adam and John were able to turn these vexations into positive ventures! I guess I'm wondering how I will do the same as I enter into a completely new context (new state, new city, new university, new position). I don't want to lose myself in the process of working toward tenure, and I always want to keep my mission to facilitate the personal and professional learning of students, teacher candidates, teachers, and community members at the forefront of my work.

Right now, I feel like I am serving two Masters: Master Tenure, representing the existing university and science education community structures and expectations; and Master Passion, representing the unwavering commitment to facilitate empowerment and positive change through education. I know this is a problem. Being educated in Catholic schools growing up, I studied the Bible as a dutiful young student should, and I recall: "No one can serve two masters; for either [s]he will hate the one and love the other, or [s]he will be devoted to one and despise the other" (Matthew 6:24). Clearly, I cannot leave this vexation unresolved. Both Masters will determine the worthiness of my work as an educator, generator, and disseminator of knowledge; they will just measure it in very different ways. I fully recognize that I cannot simply despise and reject Master Tenure if I'm going to maintain the societal position I need to serve Master Passion. But I have a great fear of becoming a devoted servant of Master Tenure, thereby squelching my passion for and commitment to professional learning and empowerment through education.

From Graduate Student to Faculty Member: Can Passion Survive the Tenure Process?

Elizabeth Coleman, *UNC Charlotte*

RIGHT NOW, AS I CONTEMPLATE POSSIBLE COURSES OF ACTION, I see myself making a conscious effort to favor Master Passion. When I think about it, I've spent much of my life checking off boxes or fulfilling requirements that are deemed essential in order to do the work of facilitating others' professional learning and personal growth. I don't realistically see how I'll ever be able to serve one Master without the other. However, I left the elementary classroom and entered my doctoral program so that I might effect change on a broader level than just my own classroom. I wanted to have a stronger, more powerful voice in the realm of education so I could advocate for students, teachers, schools, and communities. This reminds me that my venture must involve more than continuing to serve both of my Masters as I currently do now. I need to speak back to Master Tenure and the system whose structures at times only seem to protect academics' egos, rather than push for the generation and dissemination of knowledge that will actually help students, teachers, schools, and communities grounded in the real work of education. I'm just not sure how to begin doing this in a productive way.

I've already received plenty of helpful advice from others about how to balance my teaching responsibilities with my research, how to protect my time and ensure consistent research productivity, how to maintain a clear focus for my research agenda, etc. However, this is not really the guidance I am looking for moving forward. Rather, I want to hear ideas for how I might *actually* begin this venture of serving multiple Masters, while engaging in work that meaningfully enhances others' professional learning.

Specifically, I aspire to begin work in a few areas:

- In terms of my teaching, I would like to develop relationships with informal science education institutions, such as local museums, zoos, and nature preserves, so that I might provide teacher candidates with science teaching and learning experiences across formal and informal settings, modeling for them what they might do for their own future students.
- In terms of my service to the community, I would like to develop relationships with administrators and teachers in nearby urban schools, so that I might contribute ideas from my curriculum development work and help them enhance both their learning and the science learning of their students. I also hope to meet research goals with this endeavor by studying how changes in curriculum and instruction impact both teachers' and students' identity work related to science.
- In terms of my service to the department, I would like to help them as they begin revising the teacher preparation program to infuse a focus on culturally responsive pedagogy into coursework, so that we might better prepare teacher candidates to work in settings with a diverse range of learners.

I know these ventures will involve becoming entrenched in the broader context of North Carolina, Charlotte, and those smaller communities within this context, such as the university, schools, neighborhoods, and community organizations. And I have no illusion that building these relationships will be easy. I have a lot of work to do. As I reach this crossroads, moving from graduate student into a tenure-track faculty role, I would like feedback from others who have stood at the same crossroads, as well as those who have not but can approach these ventures from other perspectives. I would like to hear a variety of viewpoints as to how I might begin working on these ventures, so that I might start my future path in a way that will not only be productive, but also meaningfully prioritize the professional learning of others.

In particular, I wonder: ***How do I begin all of the relationship building these ventures will require? How do I approach my work with schools and informal institutions in a way that helps me produce research to fulfill my tenure requirements, while also keeping the students', teachers', schools', and communities' needs at the forefront? As a junior faculty member with little knowledge of the local and university context, how do I respectfully challenge the status quo and contribute to the professional learning of my senior colleagues?***

Authentic Presence: Classrooms to Playgrounds, Homework to Scholarship, Dinner to Design – All Grounded in Reflexivity

Mark Enfield, *Elon University*

THE SPRING SUNSHINE WARMS ME, energizing synapses causing a whirl of thoughts, and yet the peacefulness calms my soul. I sit in the park; two dogs nestled beneath my feet, watching children laugh and play. I revel in the dappled shade from a tree that keeps the temperature just right. Spring seems to finally have arrived in North Carolina. In this spring moment, I realize my life effuses with a multitude of breathtaking beginnings. I am joyful, peaceful, content, and even playful.

Within this spring moment I reflect on my professional life and how I support others' professional learning. Energized by the warm spring sun, I recollect events of the past year. I participated in two international experiences with students, integrated more service in my coursework, started an afterschool program, instigated and led the production of a public science event, and began thinking about post-tenure scholarly foci. Yet, my scholarly productivity reflects the year's slow start of spring with many germinating ideas, with each competing for resources to emerge and bloom. And then I am caught… jolted from revere by a shrill cry of laughter from a child on the playground vexations emerge. How does my activity fit into my overall professional life?

With the speed of bee wings buzzing, thoughts flurry through my mind. The analytic, scientific, linear side of me demands a clear logical answer, chattering like the frustrated squirrel in the tree. The chatter urges me to settle on a central and consistent concern. First, I think about bringing authenticity to teaching and learning. However buzzing thoughts raise another concern, the role of being present in revealing unexpected insights. For me, authenticity involves doing real tasks for real purposes. Being present involves a stance of full physical engagement in and mental awareness of the ongoing activity. But I realize there is a powerful connection between authenticity and presence. But, these abstractions, like the shadow play of windblown tree leaves on the ground, are difficult to connect without concrete examples.

In January, I spent three weeks in Costa Rica with undergraduate students. Among the many experiences, I remember painting houses in an impoverished barrio populated by Nicaraguan refugees. Our small army of unskilled painters was given the task of painting houses along a street in this neighborhood, clearly authentic activity. I recall my thoughts drifted with the rhythmic squeak of paint rollers and repetitious slap of paint brushes on the stucco walls. In the blazing hot sun, with no clear plan about how much we would paint or if other tasks would emerge, it became increasingly difficult to remain intellectually engaged. Clearly part of the path involves being present in those moments, but in this case my assessment is that the task and the context limited the ability of each of us to authentically engage, remaining aware of the on-going activity.

In contrast I was an advisor on a service trip working four days in a Jamaican school. This was a smaller group, a shorter trip, and did not explicitly involve academic content. The university students, none of whom were education majors, were thrust into classrooms, asked to teach, and given little to no resources. They faced a substantial authentic task – teaching young children. Each night as they reflected on the day, their thoughts, issues, concerns, and questions made it clear they were physically, emotionally, and mentally present in the act of teaching. Comparing this with Costa Rica, I see that there are many differences, but the degree of authenticity and extent to which we were present distinguish what happened in Jamaica.

A slight breeze disrupts my revere and I realize my ponderances divert my attention from my wonder about what these ideas have to do with my professional life. As an educator, it should be expected that I am concerned about learning. As someone who teaches future educators, that has layered meanings: students are learning about how to facilitate learning. I have challenged students to consider their reflections carefully, especially reflection in action, as a means to encourage professional learning. I have also explicitly taught about authenticity, describing the benefit of including real tasks for real purposes. At times this has worked, but I've struggled to retain momentum. Now, on this spring day new ideas are emerging. I am curious about the juxtaposition of these concepts. Does presence require authenticity? Will authenticity be enhanced through encouraging, scaffolding, and supporting future teachers' in situ contemplation?

RISING FROM THE BENCH, I motion to the young girl on the play structure saying, 'come on, we need to go home.' For a moment, I pause; I have made so many transitions that my life is nothing like my life of just a year ago. Anticipating the practical reality of homework, meals, and bedtime routines, I realize that

my pondering is part of another transition. As the dogs, child, and I walk home, I consider how I want to harness this energy and forge a new venture, one that integrates authenticity and presence. With the slam of the screen door behind us, I am jarred into realizing that my presence is inescapable in my thoughts and actions. I am engaged in a process of personal and intellectual transformation, which impacts how I facilitate others' learning.

Standing in the kitchen, chopping onions to prepare dinner, I realize that it is important to start close to home – myself. How can I engage my own participation in and also learning about authenticity and being present? As I ponder this question, my partner and I talk about writing and ultimately she identifies a future writing conference at a nearby university. This is the beginning and, as dinner aromas fill the kitchen, an idea about re-envisioning my own writing melds in my mind. I have taught and advocated about the power of narrative and creative nonfiction, but still find myself returning to traditional academic writing. I note that to encourage authenticity and presence with my students, that same applies to my own life. Thus, one path will entail exploring how I engage in an authentic and present scholarly life through my own professional and reflexive work.

As dinner nears completion, I think about how I need to redesign course activities and assignments to promote my core ideas. Authenticity in teacher education courses is hypothetically easy: students plan lessons that they will teach. However, in my experience, lesson planning easily becomes inauthentic; students find activities that are appealing and gloss over planning lessons as planning learning. For the future, I want to encourage the students to include authentic experiences in the lessons they plan. This will require changing both what and how I provide learning experiences for these future professionals, a worthy step toward for meeting this goal.

My musings invite me think about presence; what does this have to do with teacher professional learning? In the past I've written about reflection and the different forms and contexts of reflection. Presence is akin to one form of reflection. I have been intrigued by the idea of 'reflection in action'. It is logical that presence is necessary to reflect in action. The problem involves knowing how to teach being present in order to enable reflection in action. Thus connected to my exploration and application of authenticity, I need to revisit my thinking about reflection. I want to foreground and attempt to teach more about presence.

As this day draws to a close, I feel I have a kernel of a plan that focuses on re-envisioning the ways that I involve students – whether they are education students or students in my other courses – in learning about authenticity and presence. I want to start with my own work and myself as a scholar to develop my emerging authorial voice. This becomes a case study of being present in my own authentic work. Then, I want to consider how to apply my lived experiences to re-ignite the activity and assignments in courses I teach. I want to keep the concepts of authenticity and presence intertwined and attempt to make them seamlessly integrated in students' experiences.

My partner begins corralling her daughter to brush her teeth, get into pajamas and go to bed. We say good nights and I listen for the gentle murmurs of bedtime stories, accompanied by the soft snoring of my pug. I sit again to read and write and think about these ideas. But as the day settles to close, my thoughts relax into the moment seeing that it is possible to harmonize across experiences and see that what seems disparate may have unity. My challenge, as I head myself for bed, will be to actualize my plans and witness the outcome.

In the listless moments between consciousness and sleep, questions drift through my mind:

1. How do others navigate transitions from pre-tenure to tenured faculty? And during these transitions, what happens to the intellectual and scholarly agendas of faculty? What transitions in writing occur throughout a career.
2. As teacher educators, we create experiential artifices to develop the craft of teaching; but how do these experiences reflect teachers' work? How can planning learning experiences become opportunities to learn as well as reflective of rich intellectual engagement?
3. Finally, how have others challenged students to remain present both while learning, in their practice, and in their own professional lives?

Examining Mendel's Compost Pile: Mutated Cross-Pollination of the Vex/Ven Cycle in a Preservice Teacher Preparation Program

Steven Fletcher
St. Edward's University

LEARNING TO TEACH IS PROBLEMATIC. Not only are early career secondary teachers faced with the emotional and psychological task moving to the other side of the desk (from student to teacher) in both content and pedagogy, but they also face a daily audience of adolescent learners (up to 150 students a day in some cases) with a wide range of talents and learning styles, along with colleagues, administrators, parents, and counselors who may or may not be sympathetic to the stresses of someone acclimating to a new career. Add the current testing environment in the state of Texas, and you may see a few teachers leave the field before they start. Working as a teacher educator in functioning schools puts me in the middle of this situation, and because my interest is in building the best and well-prepared teachers possible, I am always considering new strategies to help our beginning teachers negotiate the culture and context of the public school.

My teaching methods class has an intensive internship that complements the university coursework. These internship responsibilities include planning and teaching lessons, working on pedagogical skills and learning the culture of the school. The practice lessons occur twice during the semester, and preservice teachers typically take over the mentors' class for a period (55 minutes). Teachers are asked to use digital media to record and reflect on their teaching practice. Digital video recordings are created while they teach the high school class, and then are watched and edited. In the past, I have asked teachers to identify positive and challenging moments with their teaching to then discuss in written reflections they turn in for a grade. After their final teaching event, I asked them to prepare a short summary video as evidence of their learning in class (teachers picked clips of their teaching that related to course goals) and give a short presentation during the last day of class.

First Vexation: Unfortunately, products from this assignment have typically fallen into the "show and tell" category of presentation. Teachers stood up and dutifully scrolled through a series of presentation slides and then quickly showed a few disconnected clips of their teaching, generally showcasing the more positive moments. Despite my requirement for audience participation, the results were typically underwhelming, and have left me frustrated with the shallow nature of the reflections from this assignment.

First Venture: I resolved to re-think the assignment. Effective reflection is a key element in helping teachers search for meaning in learning to teach. I wanted to create an assignment that did four things: 1. Asked teachers to ***consider their teaching practice more deeply*** to build in them a way to make sense of the larger implications of their practice. 2. Created an opportunity for teachers to ***recognize that others may share the same sets of feelings*** as they do - feelings of insecurity, anxiety, or of being overwhelmed by the nature of the profession, 3. Built a peer-to-peer dialogue (as opposed to a 'show and tell') that will ***uncover and broaden the conversation*** around the problematic nature of learning to teach, and 4. Used ***technology as a tool*** to help inform teaching and learning. To move the conversation from a routine presentation format to a deeper examination of practice, I chose to modify a presentation format first developed for the professional development of the science teacher education community by Johnston and Settlage (2008). This format is called a Vexation/Venture or Vex/Ven incubator session. I added a pre and post-narrative assignment, modified the format and timing of the incubator, and connected this assignment to the rest of the course. A brief description of the process follows.

Before the Vex/Ven: A. After teaching the first lesson in the classroom, the teachers jotted down field notes immediately to record their initial impressions of the teaching event. B. After uploading a digital copy of the video-recording to a home or university computer, they then watched the entire video and compiled detailed notes on areas that were vexing or problematic, as well as those that were positive. C. Teachers chose one vexing element of their teaching practice from the videotaped teach and wrote a one-page description of this moment or element, describing the context, setting, and milieu of the classroom (their vexation). D. Teachers edited their video-recording to isolate the vexing moment and provide some visual context for their peers. E. Finally teachers wrote a response to themselves as a way to solve this issue and proposed some corrective action during the second teach to improve their practice (their venture).

During the Vex/Ven: The presenter of the Vexation and Venture produced a problem or challenge and specific solution to the problem, and opened a conversation to the group's input on these. The vexation was shared through an edited video clip generated and was shown via laptop to the incubator group. A volunteer peer facilitator who maintained equitable contributions and the following timetable for specific stages directed these sessions. Participants offered suggestions, support, or proposed alternate perspectives to the problem / vexation.

After the Vex/Ven: After the incubator sessions were completed, teachers individually wrote a narrative reflection from the Vex/Ven session that recapped the main themes from the conversation around their Vexation and Venture along with general reflections from the group. Teachers outlined steps for change (ventures) for the next teaching episode to address the vexation. For the narrative, teachers listed the positive and challenging elements of the teaching experience to help them prepare for the next set of lessons. They also considered any evidence of student learning, examined their assessment strategies, and summarized the Vex/Ven incubator experience.

Connections to the rest of the course. Teachers prepared another lesson and taught two more times to the same group of students later in the semester. The goal was to practice the venture from the outset as well as continue to build confidence in front of students. At the end of the semester, teachers compiled three more teaching clips showing the changes they had made to their practice (as evidence of their venture) and provided written feedback on how the second round of teaching went. Faculty observations of the teaching moments show that the majority of teachers made specific

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efforts to remedy problematic practices. This effort is also highlighted in the student narratives. One student remarked "The incident from Teach 1 that I found challenging was that I did not get the students' attention before I started giving directions. This was an issue because I basically froze and just let the students be in control of the situation, not the other way around. In Teach 2, I made sure the class was quiet and paying attention to what I was doing before I started to ask a question. Once I did ask it, I made sure the students understood by asking another student to tell why he put the answer he did. I felt like I made the better choice in Teach 2 partly because I was more comfortable with teaching the class since I had already taught them and also because I remember what I did (during the first teach) and how I felt last time!" Another student wrote, "I felt extremely well prepared going into the second lesson and I believe the biggest thing I took away from Teach One that I integrated into Teach Two would be my delivery. I made sure to break up rules and instructions and consistently asked the students if they understood or not. This was also my vexation from the first teach, so I made it a point to correct my behavior and be clear in instructions for my second teach. Although I still need some practice, I believe I did a much better job the second time around."

There is some evidence that this assignment impacted the professional learning of the teachers in the course. Examination of teaching narratives from the semester indicated that focusing on specific moments of vexation provided common and shared ground for the teachers. There was a real sense of relief from the teachers when they realized that others in the class struggled with similar issue. One student remarked, "The Vex/Ven session with my peers was very helpful. I enjoyed watching the other videos and realizing that we all do similar things that are considered mistakes or some really great things! This experience was probably better than I anticipated. Since we had to videotape the lesson, I felt self-conscious about watching the video. Once I did, I enjoyed watching the things I could improve on. I will go into the next teach more prepared because I plan to utilize the suggestion given to me by my classmates." Another wrote, "The Vex/Ven incubation experience was good. Overall, having an open conversation about all of the anxieties that accompany becoming a teacher with other starting teachers is fantastic. The feedback I received was helpful, but really just talking out loud with others who understand what it is you're going through is priceless."

Second Vexation: So everything looks great, right? Student reflections have focused on important elements of professional development, including growth in being seen as part of a professional community — one that shares similar concerns and fears. There is participation and real conversation around authentic issues related to beginning to teach. Despite these gains, I continue to feel as though there is something missing from this work. We've starting something important, but the results are still fairly shallow in my opinion. The work of Fuller (1969) and the resulting Concerns Based Adoption Model (CBAM) that emerged from her work and that of others (Hall & Hord, 1987) focuses on the concerns that beginning teachers describe as they progress into the field. Researchers understand that this model is not linear, but that there is a general movement from concerns of self to later concerns of impact on student learning. Teachers can hold more than one level of concern based on their experience, comfort and the context of the vexation they face in the classroom. My vexation with this assignment as it stands is that it is still a snapshot model of reflection. Teachers are quick to find problematic elements in their practice and can articulate solutions. I am not certain that they are digging in to some of the complexities of what it means to teach. The assignment requires refinement. I'd like to add a final piece that requires the group to develop assertions about their teaching from the incubator conversations. This might help teachers reconsider assumptions/biases as well as build more generalized ideas about teaching practice, rather than assuming their peers issue/vexation is isolated. Also, more refined assessment tools are needed to measure the value and success of this tool programmatically.

I seek feedback on how to build a deeper level of authentic reflection/action/reflection from them during this process.

Second Venture: I have developed two other assignments in other St. Edward's University teacher preparation program courses that create a sequential pathway for reflective practice using the Vex/Ven cycle as a core element. These assignments have been adopted by both elementary and secondary programs as tools to show some type of teacher development through our program.

Title (Teaching experience)	Micro-teach (None)	Vex/Ven incubator (Little)	Video Club (Some)
Questions the teachers are to ask when reviewing their video	What do I notice about myself as teacher? (noticing literature)	What vexes me about my teaching? What can I do to change? (Vex/Ven)	What evidence is there of student learning from my teaching? (video analysis)
Course/year	Junior/Senior Block1	Senior Block 2	Student teaching
Stage of concern	Self	Task	Impact on student learning

Our teachers seem able to consider various perspectives, think analytically about their practice and change their teaching accordingly. Whether that is due to this assignment is a question that I think would be really hard to pin down, given the complex contextual factors that impact teacher development. I can say that the students seem to gain confidence, skill with the video camera, and seem to fit into professional communities with ease. I'd like to know more about how and if this set of tools can impact them in a long-term way. Any advice appreciated.

Re-contextualizing Self: Educational Researcher, Teacher Educator, Assistant Professor

Brian Scott Fortney
Texas Tech University

AS I WRITE MY VEXATION/VENTURE, I FIND AN ODD DISCONNECT. I am sitting at a desk placed next to the window of my office in the education building, and listening to sounds associated with elementary and middle level students at play. There was no notice of the visit to the College of Education by local public school students. Too, when asked, colleagues did not know where the students were from, nor why they were visiting. I highly value opportunities to connect with classroom teachers and students in my community, and this was a lost opportunity. Recently, forbidden opportunities for developing communication between classroom teachers and faculty have been reevaluated for select faculty in the college of education/teacher education; however all communication must be approved by my supervisor – research and all. Besides research and publication goals, my role is to teach science methods courses in Elementary, Middle Level, and Secondary certification programs, and work with preservice teachers. Having access to classroom teachers and students is critical for my teaching and research in teacher education. ***Forbidden or restricted access is such an odd disconnect from my past experiences***. Indeed, as my department wrestles with issues of academic freedom, I continue to find myself forced to fight for every minute of research time that is expected with an assistant professor position. Having completed my first year as an Assistant Professor in a department embroiled with change, I look forward to expanding my venture and successfully maneuvering between political agendas.

The above disconnect highlights my experiences as a new tenure-track assistant professor, and this paragraph provides a few explicit details before my venture. Across multiple levels, multiple interpretations of an assistant professor's job description exist. The description at lower levels of university administration is dissimilar with the expectations of upper levels of administration, resulting in a staggering number of committee assignments (13) and expectations not conducive to initiating a research agenda in preservice teacher education as a new faculty member. My vexation is crafted from a positive, proactive perspective with my venture outlining current efforts to re-frame my research agenda. Generally, I am concerned with understanding how a preservice/beginning teacher's beliefs shape their classroom practice, or pathways in which preservice teachers make decisions about responses to students, and teaching behaviors in the classroom.

My venture seeks to recapture creativity in writing, time needed to write, and to maintain "positive intellectual pressure" in a department wracked with change. I seek guidance on how to frame "publications that help me achieve tenure" while I continue working on developing various aspects of belief/practice pathway development in preservice teacher belief systems. In short, what might I do to proactively develop *structure* that will support my research agenda (while I am forced to work on others' research) such that I am able to think deeply about the development of preservice and beginning teacher beliefs and practice in authentic classrooms?

Beginning Steps: Spring 2014

In January, I began closing the door to my office, and have stopped asking questions that result in emergency meetings. I stopped attending "compulsory" meetings once I learned my Department Chair did not sanction them. I submitted my first manuscript for review in April, have received helpful feedback, and have initiated a symposium for AERA and NARST designed to focus on equity in science teacher education. I am presenting research papers at each conference. The symposium team has invited authors representing multiple aspects of equity-focused perspectives in Science Teacher Education to write and present a poster (with paper). The process is designed to facilitate dialogues across multiple perspectives and methodologies focused on equity in science teacher education. Ultimately, the papers will be synthesized into an edited volume of work. I continue to co-author work in Informal Science Education, and have initiated a co-authoring process linked to my teaching. I continue to work at being proactive, and developing of structure that will support future research and publication efforts. I am trying to do what is assigned, quickly and efficiently, and carve out time for developing my research agenda. There is no cure for the politics. I am seeking advice and "out of the box thinking" to strengthen my research agenda, creativity, and writing, in the time allowed.

Re-contextualizing Self: Educational Researcher, Teacher Educator, Assistant Professor

Brian Scott Fortney
Texas Tech University

MY RESEARCH INTEREST RESIDES IN ANSWERING A QUESTION posed by Patricia Simmons et al (1999) "How are beginning teachers' belief systems congruent/incongruent with their actions in the classroom?" (1999, p. 950). In addition to explicit defining of terms such as belief, belief structure, and attitude, I use Eleanor Gibson and James J. Gibson's ecological approach to perceptual learning and development to interpret the perception-action link as mediated by beliefs and attitudes held by preservice science teachers as they learn to teach inquiry in science. My current preservice teachers are entering into their yearlong student teaching semester, and I will follow them into their first years of teaching. Each aspect requires specific data sources, including video data, interview data, and access to public school classrooms, which I have just been granted "restricted" access. All this set within an excessive testing environment which leaves students exhausted, with minimal time to collaborate on assignments.

While working to recapture creativity in writing, time needed to write, and to maintain "positive intellectual pressure" in a department wracked with change, I seek guidance on how to frame "publications that help me achieve tenure" while I continue working on understanding various aspects of belief/practice pathway development in preservice teacher belief systems. In short, what might I do to proactively develop *structure* that will support my research agenda (while I am forced to work on others' research) such that I am able to think deeply about the development of preservice and beginning teacher beliefs and practice in authentic classrooms?

As an aside, regarding video capture, my department utilizes TeachScape and iPods/iPads to record and upload video data. Each student in our teacher education program is required to record 4-8 of their lessons per semester, with (a minimum) reflection on intended and actual teaching behaviors in each lesson. Each student is required to upload lesson plans and additional artifacts pertaining to that particular lesson, to a central server. This record-upload-evaluation procedure has already been institutionalized-one positive aspect. On the other hand, I have been required to change my job duties to primarily focus on program evaluation of quality of science content knowledge held by preservice teachers primarily utilizing the repository of digitally recorded lessons, often of poor quality with no supporting transcription help or accompanying artifacts. None have been approved for use in research or publication. While there is faint hope for publication, the process is a slippery slope colored by semantics, and politics, and I have been directed: "This is not for publication."

Given the vexing political situation, I struggle to frame manuscripts that embody my work on understanding how preservice teacher beliefs impact their perceptions and decisions in the classroom, while learning to teach. Further, my current preservice teachers will soon graduate, and begin teaching in local districts, positioning my work to continue forward as they progress through their beginning years of teaching.

In sum, my venture seeks to recapture creativity in writing, time needed to write, and to maintain "positive intellectual pressure" in a department wracked with change. I am looking for partnerships in writing regarding aspects of teacher education, suggestions, and/or out of the box thinking, as well as advice on things I may not have considered.

Where is the Teacher in Research on Science Learning?

Erin Marie Furtak
University of Colorado at Boulder

ENVISION AN EDUCATIONAL RESEARCH CONFERENCE SESSION IN 2015, held in a nondescript hotel room somewhere in the US. The presenters come up to the podium one by one, each presenting results of research conducted in K-12 classrooms. They rationalize their research by citing STEM policy reports that indicate an urgent need to improve student performance in science, and seize upon the recent release of the *Next Generation Science Standards* ([NGSS]; NGSS Lead States, 2013) as an opportunity for identifying mechanisms for doing so. The main findings of each study are as follows:

> Study 1: *"We spent two years collaborating with scientists to develop a new* NGSS*-aligned curriculum which engages students in developing a model that describes how the total number of atoms in a chemical reaction does not change (MS-PS1-5). We found that students who had the curriculum had a better understanding of the conservation of mass than those who did not."*
>
> Study 2: *"We developed a tablet-based interactive tool to support students' engagement in the scientific practice of analyzing and interpreting data. We found that students who interacted with the tool were engaged in scientific practices."*
>
> Study 3: *"After studying how middle school students use information from several sources to provide evidence that Earth events can happen slowly or quickly (2-ESS1-1), we created a learning progression that illustrates how student understanding of this concept develops at this grade band. We also developed a set of items linked to the learning progression, and a Wright map shows how the items clearly illustrate a progression between levels on our learning progression."*

Each of these studies focuses on an innovation aligned with the NGSS and then draws conclusions about student learning, as shown in Figure 1. I do not wish to criticize the findings of these studies in and of themselves, as they all clearly make contributions to our understandings of how students learn in alignment with the ambitious agenda set forth by the NGSS. This is not the issue. However, my vexation is that each of these studies skips over essential elements of the classrooms in which the research took place: the teacher, his or her instructional practices, and the nature of his or her own learning experiences inside and outside the classroom.

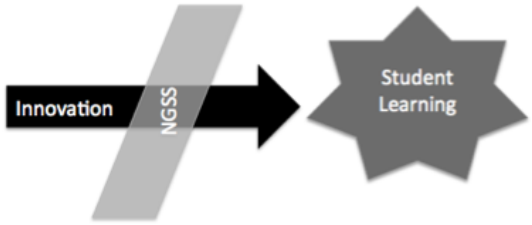

Figure 1. Model for Studies 1-3 1

Study 1 connects the creation of a new curriculum with increased student learning, but omits the role that the teacher played as interpreter and enactor of that curriculum. Study 2 involved the creation of a new technology to support learning, but it is not clear if the teacher was involved in facilitating the learning, responded to student questions, or otherwise helped with the enactment of the technology. Finally, Study 3 explored how student learning develops in a domain without an accompanying focus on instructional strategies that supported that learning.

In part, these studies can perhaps not be blamed for overlooking the role of the teacher. Indeed, both the *National Science Education Standards* (NRC, 1996) and the NGSS (NGSS Lead States, 2013) dedicated the vast majority of their pages to delineating what students should learn in science, not necessarily how they should be taught, and how teacher learning might be supported. While the addendum to the 1996 *Standards* (NRC, 2001) and the NGSS (BOSE, 2012) highlighted ways in which teachers might be supported in learning about each set of standards, and how teachers might help students meet the standards, these additional writings are rarely the centerpiece of the vast media coverage dedicated to the standards, nor are they a focus of the majority of research in science education.

This is a greatly troublesome issue as decades of research have indicated the repeated 'failure' of the teacher workforce to raise the quality of its teaching practices in order to improve the quality of student learning. Indeed, with the 'apprenticeship of observation' working against it (e.g. Lortie, 1975), teachers have an uphill battle to learn about new practices and push beyond the bounds of what they currently know and are able to do. If the teacher's own process of learning remains a shadow in these studies and not a direct object of study, we will continue to churn out high-quality curricula, instructional tools, learning progressions, and content

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assessments aligned with the NGSS that have the potential to increase student achievement in science, but will be perpetually disappointed by their implementation with real teachers and in real classrooms.

MY VENTURE IS TO SEIZE THE OPPORTUNITY of the release and adoption of the *NGSS* to call attention to the importance of research that explores professional learning environments for the majority of the science teacher workforce. This would expand the shaft of light currently – and intensely – focused on student engagement with the disciplinary core ideas, scientific practices, and crosscutting concepts in the *NGSS* to focus also on the teacher's practices in engaging students in them. Furthermore, it would direct light at the closed-door professional development settings in which teachers learn, reorienting our focus on the process of teacher learning in and of itself, not just as a means to the end of student learning. This venture is represented in Figure 2.

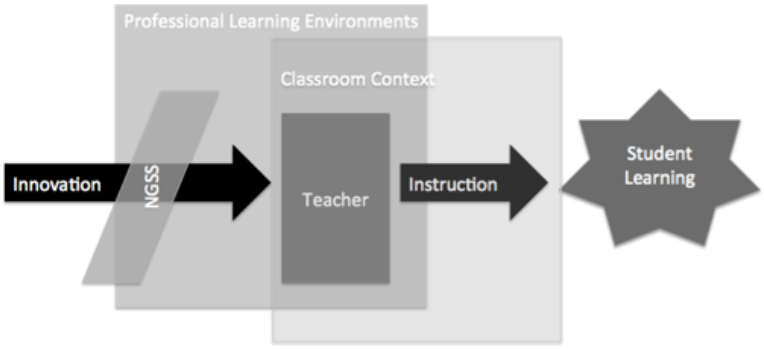

Figure 2. Model for My Venture: A New Focus on the Teacher

Figure 2 illustrates several mediating steps between the innovation and student learning model in Figure 1. First, it includes the teacher as the enactor and interpreter of the innovation aligned with the *NGSS*, as well as that teacher's instruction as they connect with student learning. In addition, Figure 2 includes the important elements of the professional learning environments to which teachers may or may not have access, and which provide opportunities for the teachers to learn more about the innovation and the *NGSS*. This professional learning environment overlaps with teachers' classroom contexts, which encompass their students, the tools to which those teachers have access to support their instruction, and which may also be brought into professional learning environments.

My venture will have two parts: one which I can begin now, to inform my future work in this area: to conduct a systematic review of the research on teacher learning in professional development through the lens of K-12 science teaching, with recommendations to the field for future areas of research. This review will build upon the rich literature base available in other areas of educational research, which has held the teacher and his or her process of learning about ambitious teaching practices as an object of study for many years (e.g. Horn & Little, 2009). In particular, researchers in mathematics education have created a number of models for designing and studying professional development contexts, and have linked teacher learning in those contexts to classroom practice (e.g. Borko, et al, 2008; Kazemi & Hubbard, 2008; van Es & Sherin, 2002).

The second part of my venture involves engaging multiple stakeholders – teachers, administrators, researchers, and policymakers – in a sustained conversation about the essential role that teachers play in implementing the NGSS. Numerous attempts to reform the educational enterprise have come and gone in recent decades, and while each has resulted in small changes, the large overhaul of science education that is co clearly needed has still yet to occur. How can we make sure that the NGSS reforms are different? More specifically:

- How can we guide NGSS research to encompass teachers and their development, in addition to student learning?
- How can we facilitate conversations about the NGSS and the Common Core movement to include meaningful conversations about supporting teachers in making ambitious changes to daily practice?

It is my vision that a conscious and systematic focus on the teacher and his or her learning environment will help us more fully realize the potential of the NGSS, and will leave us with better understandings about how teacher learning relates to student achievement in science.

Conceptions of Researcher Growth and Professional Development

Rachael Gabriel
University of Connecticut

LAST FALL, I WAS ATTENDING A CONFERENCE ON SCHOOL-UNIVERSITY PARTNERSHIPS with the principal of a school I had recently begun working with weekly for various projects related to teacher professional development. Having each slipped out of sessions that weren't what we thought they would be we met in the hotel bar to brainstorm ideas for the school in quiet. Stationed comfortably on a stool at the bar, the principal asked me: "if you could do anything to make our school stronger and your school stronger, what would it be?" The project we sketched on a bar napkin came to fruition a few months later as "The Collaboratory" — a partnership between his school and our university in which teachers and researchers generate and discuss individual problems of practice in protocol-guided discussion groups we have carefully constructed to provide a diverse and supportive audience for each individual's question. We meet almost monthly and aim to tackle "problems of practice" for both teachers and researchers — using one as the other's resource and sounding board. I imagined a two-way exchange where teachers and researchers learned from each other and, at times, blended and traded roles.

The Collaboratory was an easy sell to people who are used to the idea that teachers need professional development, and researchers can give it to them. After all, it blended familiar ideas about teacher learning from research on Professional Learning Communities, Critical Friends Groups and collaborative learning "labs." Though the mechanism for supporting teachers was clear, the reciprocity between teachers and researchers — and the idea that researchers would learn as much about by engaging with teachers — keeps getting lost in translation. For the teachers, the Collaboratory is professional development. For the researchers, it is service.

Here's what's vexing: It should be both. It should be an antidote to empty plugs from university officials to increase "engaged scholarship" as if it's a form of community service that earns brownie points, rather than the highest form of applied research. It should be an opportunity for researchers to (re)ground themselves in the contexts, bodily realities, languages and problems of everyday classroom practice in a way that informs everything from their research agendas to the ways in which they disseminate findings and partner with teachers to extend what they know. In other words, it should be about ensuring that "local" or "practical" knowledge is not only acknowledged, but used to enrich theoretical and empirical endeavors. I want to be able to demonstrate that researchers get "better" by engaging in meaningful work with teachers, but I'm not sure how to do it.

The lack of an articulated model of researcher development has both theoretical and methodological consequences. Theoretically, it has made it more challenging to argue that this process is mutually renewing, democratic or even worthwhile for researchers. This impacts recruitment of researchers as participants as well as the implied positioning of participating teachers as the students or recipients of research. Methodologically, the lack of an articulated model for researcher development makes it difficult to measure the success of the project. In fact, the more we have to demonstrate impact in order to sustain funding, the more the Collaboratory has been constructed as a one-way teacher professional development project. This is simply because we know how to conceptualize "impact" as development or growth for teachers by observations of practice (proximally) and (distally) student outcome measures. Research, on the other hand, is most often measured in terms of productivity, funding or, rarely, generativity. Neither of these measures indicates growth within the researcher (proximally) or improvement in the research (distally).

I don't know how to think or talk about what development for researchers means, let alone how it might be identified or measured. Without this, I don’t have a way of building an argument that there could be change, growth or improvement for researchers as a result of engagement with teachers. With it, I could test the assumption that engagement with the field is important, and examine the extent to which field-initiated or engaged scholarship is mutually beneficial.

I want to leave room for the possibility that research and researchers are too diverse to fit a model that would allow such measurement. The same is probably true of teaching and teachers given varied conceptions of the purposes of schooling. Still, without a way of thinking or talking about trajectories of development for researchers, I don’t have a way of building an argument that there is change, growth or improvement as a result of engagement with practitioners.

Conceptions of Researcher Growth and Professional Development

Rachael Gabriel
University of Connecticut

ONE UNSATISFACTORY WAY TO APPROACH THIS DILEMMA is to argue that the "practice-to-research gap" is as important as the "research-to-practice gap," and guilt researchers into a heightened sense of responsibility for closing the gap. Still, the interpretive repertoire (Wetherell, 1998) of "gaps" in education, besides being normative and deficit-based (Royal, 2013), seems to be the wrong metaphor. This isn't a gap, it's a difference: in the histories, constructions and conceptions of the two professions, and in the rhetorical tools that are used to define them. Researchers often measure or hold mirrors up to teachers, but this rarely goes the other way. Teachers and researchers often taken on multiple identities, with people self-identifying as teacher, researcher and student within the same conversation. Teaching and research overlap, but the roles that accompany these pursuits are different.

One of the differences is that researchers can take or leave a responsibility to directly support student outcomes and still earn awards, regard and tenure for contributions to research or policy, rather than practice. Indeed researchers may hold any number of models for what counts as success in academia, or what counts as personal or professional success for them as individuals. Research endeavors are so varied and risky by nature (as adults, we ask questions for which we do not have answers) that it may be ill-advised or impossible to sketch a framework of development or expectation of outcomes that applies to educational researchers, or even a subset of them.

Nevertheless, there is a body of research on the development and mentoring of academics, and development and mentoring in professional fields in general. Perhaps an exploration of this literature would provide the language and/or framework for considering what participation in The Collaboratory does for researchers. Perhaps this framework could be investigated using data generated by the ongoing activities of The Collaboratory.

Alternatively, we could study researchers' perceptions of the impact of The Collaboratory and its relationship to their professional goals, or their goals for research. Research, like teaching, is tied to varied traditions, beliefs and epistemological frameworks and thus cannot all be measured in one way. This more emic approach may provide more meaningful data for the improvement of Collaboratory structures, but may not have robust connections or implications beyond this particular project.

It is also possible to do both a review of related research on professional development in academic or research fields and a bottom-up investigation of what researchers name development. Or perhaps a simpler answer exists than those I have imagined. Either way, I want to be sure I'm starting from the most open and generative place when trying to construct an understanding of possibilities for envisioning researcher development and the improvement of research in order to avoid unnecessary reduction in complexity on one hand, or the duplication of effort on the other.

Questions for discussion:

1. Is there a way to conceptualize value to researchers besides growth?
2. If the measure of teachers shift from student achievement to something more personal like perceived value, or satisfaction or self-reported learning, would the project lose standing?
3. Is it possible, and if so - important, for the teacher and researcher measures to match?

Measuring Situated Learning

Michael Giamellaro
Oregon State University-Cascades

AS ANY FRESHLY MINTED TEACHER SHOULD BE ABLE TO RECITE, it was John Dewey who introduced us to the idea that learning is inextricably related to experience. Perhaps that new teacher's roommate, a philosophy major, might counter that it was the Greeks who came up with the notions of *praxis* and *poesis*, both processes of knowing through experience. Should they have third roommate majoring in anthropology, it might become clear that experiential learning is the oldest form of teaching and intentional learning. Regardless of who we wish to credit with the idea, most of us recognize that ***experiences are either very likely to lead to learning or inevitably do so***. The learning may not be culturally or societally relevant but it happens. Within our society the pendulum seems to be swinging back toward acknowledging the role of experience in learning and knowing. The Next Generation Science Standards, for example, are based on performance expectations or knowledge held in practice rather than abstract knowledge disarticulated from the real world. There is a (re)growing recognition that learning through experience in context fundamentally changes the learning process. Despite this, ***there is still a sense that contextualized experiences are a black box that lead to student learning and engagement but through poorly understood mechanisms***. The literature on contextualized science education collectively shows variable results in cognitive learning but a closer look reveals examinations of quite different phenomena and measures that do not appear to be capturing the same types of knowledge.

While I have experimented with numerous theoretical frameworks to better understand the relationships between learner, experience, and environment, I have most consistently settled on situated learning theory with a nod toward distributed cognition. In its general sense, situated learning theory describes the process of learning as an action in a complex social, cultural, and physical environment (e.g. Greeno, Collins, & Resnick, 1996). Learning is not just 'in-the-head' but an entwined process irreducible to the component parts (Perkins, 1993). It is an experience that unites the learner with the context. The notion of distributed cognition adds the process of thinking in conjunction with external elements, whether storing notes in a notebook, 'group think', stimulated recall, or community-wide regeneration of iterative ideas (Brown, Collins, & Duguid, 1989). Situated Learning Theory is compelling in its ability to capture the many and complex layers of the processes of learning and knowing. One can readily conceptualize the learner as embedded in an environment in which information is flowing and changing between elements, including other actors and the physical environment, and only forming as a result of those interactions. Learning, then, is a system more than a process or an outcome.

Conceptualizing learning as a complex system is easy; measuring or truly understanding that system is my vexation. If knowledge is held in contextualized practice then how can we accurately capture a representation of any individual's understanding? Can we truly understand a system by focusing on only a very limited part? If we administer a test following a learning experience, particularly an experience in a contextualized environment, can we accurately capture a representation of that knowledge held in practice? Such testing represents a new context and moves from the Greek notion of *praxis* to *theoria*, a fundamental violation of construct validity. Even a performance assessment introduces a new context and we must question if a learner's situated understanding is the same or parallel in vastly different settings. If knowing is an interactive system rather than a simple process or a *residue* then how can it be measured accurately? This difficulty has ramifications for research, assessment, and instruction. This vexation can be summed into the question, ***how can we accurately measure situated knowledge***? In other words, ***can we communicate another person's systemic knowledge?***

Even more simply than 'how', we could ask *what must be measured to claim that we are accurately capturing situated learning*? We can measure any number of actions but it is not clear what they would tell us about learning or knowing, particularly if we are interested in a specific domain, such as science content knowledge. If knowing is inseparable from the actions in context, what should be measured in a post-hoc assessment? What should be measured *in situ*?

TO BETTER UNDERSTAND SITUATED LEARNING AND KNOWLEDGE I have been studying secondary science classes during field immersion experiences (e.g. Giamellaro, 2014). The situated nature of students' developing knowledge seems more likely to be apparent in these field settings than in

classroom settings where the content is not as naturally or logically situated in the context. I have recorded some limited video and audio of these events and have gathered extensive data directly from participants following the events. These data include pre/post network representations of their domain knowledge and interviews about their experiences. For example, I have been able to show changes in how students organize their knowledge of ecology through a network methodology (See Giamellaro, 2014). With these network models we can compare a student's developing knowledge to experts' and we, as researchers or teachers, are offered a glimpse into students' systemic understanding of the topic. However, **a student's existing knowledge is not a complete representation of the learning process.** This distinction is important for teaching as the disconnect between the two represent leverage points where the teacher could enhance student learning. In addition to modeling knowledge organization, I have typically also asked students to describe their learning processes and/or their current understanding of particular science concepts. I believe that I am approaching an accurate representation of their situated understanding but there is a 'once-removed' quality that leads me to believe that I am still capturing more *theoria* and not much *praxis* or *poesis*.

I am still challenged by the need to collect data truly *in situ*, when and where the learner's knowledge is being situated. I need to simultaneously be in the context and "in the learner's head." Video recording is one way to move closer to this dualism. I have just launched a study using 'point-of-view' cameras attached to individual students. The cameras capture the full audio/visual experience from an individual learners' perspective. This method allows me to capture an external view of the learner's experience from their perspective, hearing what they are hearing and seeing in their field of view. I can record their actual interactions with other actors and with the physical environment as they (assumedly) construct both targeted and peripheral knowledge situated within a specific environment. I can compare different learners and the teacher. I can see what they are writing in notebooks or doing with digital devices. I can hear and code their discourse and I can interview them post-hoc to ask about video segments.

Despite this, the vexation remains. There is a once-removed quality to the data. Of course this is in some ways the ever-present vexation for learning research, the inability to truly know what the learner is thinking or processing. Using the Situated Learning Theory lens though, we move outside of the individual learner's head to examine the full scene, the systemic learning event. It is also clear through this lens that the full "blooming, buzzing" learning experience is contributing to the knowledge, such as is represented in the network models. There are a few points of discussion that I am wrestling with and would find worthwhile to hear others' thoughts on:

1. Is it is even possible to use a snapshot of knowledge to represent situated knowledge or does taking such a snapshot inherently de-situate that understanding to a point where it is another thing altogether?
2. Given the ability to see and hear most of a student's external learning experience, what observable key indicators could be used to link this situated learning process with knowledge representations?
3. Similarly, how can I identify situated knowledge within the video data (*praxis)* that is not represented in snapshots of knowledge or assessments (*theoria)*?

While this vexation and venture may at first blush seem to be entirely academic, I foresee them as quite applied to the practitioners and pre-service teachers I work with. In teaching others how to utilize contextualized learning in science education, the difficulty of assessing situated ways of knowing consistently comes up as a barrier to implementation. In thinking more about how to measure or capture situated knowing, we can advance assessment associated with these pedagogical and curricular approaches. I believe this is particularly important for formative assessment in the moment as teachers guide their students to master NGSS performance expectations or any other canonically-grounded expectations.

The Case for Faculty Engagement with the K-12 Community

Holly Godsey
University of Utah

I WAS RECENTLY INVITED TO TAKE PART IN THE CURRICULUM REVIEW AND REVISION process for the Department of Geology and Geophysics at the University of Utah Actually, that's not true. I was not invited, I *asked* if I could be on the committee. As a PhD geoscientist from said department and as Assistant Director of the U's Center for Science and Mathematics Education with 11 years of experience in education, I felt I had something to bring to the process. I thought my colleagues would be interested to learn that we did not need to reinvent the wheel and that there had been a national effort at the K-12 level (i.e., the *Next Generation Science Standards*) that could help frame our outcomes in terms of disciplinary core ideas, crosscutting concepts, and practices. Unfortunately, when I proposed that we look at the *Framework* and *NGSS* for ideas on how to address our own curricular issues, I was met with blank stares, multiple throat clearings, and a general sense that I was "not one of them" despite three degrees in Geology and a stint in the oil industry. It turns out that the notion that those in Higher Education can learn a few things from those involved with K-12 Education is a non-starter in most academic circles. Don't get me wrong, I believe that science should drive the creation of standards and curriculum, and not the other way around. But the substantial, systematic process that went into the development of the NGSS, and the resulting emphases on the importance of scientific practice and interdisciplinary thinking, is worth noting in the world of Higher Education.

This reluctance to engage with the K-12 community stems from multiple factors, not the least of which is the low priority of teaching in many R1 institutions. Compound this with a lack of any real recognition or reward system for faculty that participate in activities that benefit K-12 (in fact, in many cases there are *dis*incentives to engage!) and a highly competitive research environment, and you end up with few faculty willing to be involved in any substantial way. This disconnect between those who are actually doing science and those who teach science has implications for the development of standards, curricular materials, pedagogical practices, educational policy and the pipeline of students entering STEM fields in college, and ultimately, the workforce.

One of the most prominent manifestations of this is in the area of the geosciences. Utah is a state rife with natural resources, most of which owe their existence to the unique geology of the region. Our economy and livelihood is highly dependent upon understanding and managing these resources in a sustainable way. The mining (coal, salt, copper, etc.), oil and gas industries have formed the cornerstone of our economy for decades. Utah's National Parks, and most State Parks, owe their designation to the geology contained within their boundaries and form the basis for our tourism industry. Utah's 'Greatest Snow on Earth' is due to the unique geographical/topographical/hydrological setting of the Wasatch Mountains. It is this same setting that causes us to have the worst air quality in the nation. Geology determines what can grow where, how quickly vegetation can recover from disturbance, and the availability of arable land, hence impacting the agricultural and forestry industries. As population burgeons in the state, natural hazards are becoming a bigger problem as building expands onto landslide-prone slopes, flood-mitigating wetlands are paved over by highways, and development continues along the seismically-active Wasatch front. Perhaps most importantly, the quality and quantity of water resources are becoming threatened as populations grows in this 2nd driest state in the nation. Beyond developing the future scientists that will address these issues, we need to recognize that every citizen in Utah is impacted by the geology and will be asked to make political, economic, and personal decisions based on their understanding of the Earth.

Despite all of this, Earth Science has a low status in our K-12 educational system. If offered at all in Utah high schools, Earth Science courses are typically taught by teachers with degrees in Biology or Chemistry. "Science-minded" students are typically steered away from the course in favor of Biology, Chemistry and Physics, and most students exit the K-12 system with little understanding of Earth Science beyond being able to name the three kinds of rocks. This problem is compounded by the lack of recognition of Earth science as a "lab science" by legislators — most of whom were educated in the same system. The results of this inattentiveness to Earth Science are few high school graduates with a fundamental understanding of the Earth and even fewer who opt to pursue scientific research in this area that is so vital to the sustainability of our state's resources and economy.

To be clear, I don't entirely blame the faculty members in my department for this predicament. But I do think that they could make a big impact by becoming involved with K-12 education. I was thrilled to see the increased emphasis on Earth Science in the NGSS. But I am concerned that in Utah's adaptation of these

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standards (since we will not be an NGSS adoption state) that Earth Science will continue to take a back seat unless researchers champion the cause and provide meaningful input on how it should be taught. In an ideal world (in my mind, at least), Earth Science would be taught as a 12th grade capstone course because in order to teach it in a meaningful way, you need to have a foundation in chemistry, physics, and biology. But, in order for this to happen, more people that are actually experts in Earth science need to become aware of what is happening in the K-12 community and contribute to the conversation. If this does not happen, we will likely see standards, curriculum and teaching practices developed by bright, well-meaning biology and chemistry educators who "love rocks", but don't have the background to bring depth to the subject of Earth science or to teach geoscience practices.

MY PROPOSED VENTURE HAS TO DO WITH THE MASTERS OF SCIENCE for Secondary School Teachers (MSSST) program at the University of Utah. This is a cohort program that helps experienced teachers improve their content knowledge and science practice skills while taking part in a lively, professional learning community. In 2009, we introduced a research experience into the program and partnered teachers with faculty across campus. The results were mixed, but promising. ***Many teachers felt that the experience of working in a lab, interacting with graduate students and faculty, and taking part in an actual research project was enlightening, but weren't quite sure how to translate the experience into better classroom teaching.*** Likewise, many faculty thought the experience was useful ***for the teachers***, but didn't recognize any benefits to their own work.

A subset of the teacher-faculty pairs, however, reported a mutually beneficial experience that helped them better understand science and how to better communicate science. What did this group do differently? The faculty actually spent ***time*** with the teacher, learning about their background and what they do in the classroom. This small effort resulted in opening lines of communication that allowed for a more even exchange of ideas and the realization that teachers have much to give to the experience, as well as much to gain.

My proposed venture is to facilitate more meaningful interactions between teacher-faculty pairs by involving the faculty member in expressing their research in terms of the practices and cross-cutting concepts of the Next Generation Science Standards (NGSS). The teacher and faculty member could be asked to create a joint proposal prior to the actual research experience that explicitly requires alignment with the NGSS. Another possibility is to ask the faculty member to commit to visit the teacher's classroom at least once, perhaps even teaching a lesson about his/her research.

The problem now becomes finding faculty members who are willing to spend the time needed to engage in a more meaningful way. It is already difficult to recruit faculty mentors for the teachers so adding more responsibilities may make the task nearly impossible. Reluctance of faculty to engage in more than a cursory way is due to a number of reasons: 1) lack of time, 2) lack of interest, and 3) lack of incentives. While lack of time and interest can't be helped, providing incentives for faculty to mentor a teacher may make a big difference.

But what should these incentives be? Salary supplements or stipends for the faculty are probably not going to be that effective simply because the amount that our program could offer would be miniscule. Stipends for graduate students or lab supplies might be slightly more appealing. Publicly acknowledging the faculty's participation or presenting an award is a nice touch, but provides little value for actually motivating someone to give up precious time. For some faculty, particularly those not yet tenured, rewards that are in line with retention, promotion and tenure procedures may be the best incentives. Although service and teaching are currently recognized in this process, in reality they hold very little weight compared to research. For other faculty, just the opportunity to contribute to the development of a teacher is reward enough. Maybe the answer is to simply recruit from the latter group. However, I believe that in order to change attitudes toward engaging with teachers and the K-12 system, we need a meaningful, university-wide reward and recognition process that places real value on this important work.

Thinking about the Size and Scope of High-Leverage Practices in Novice Teacher Professional Learning

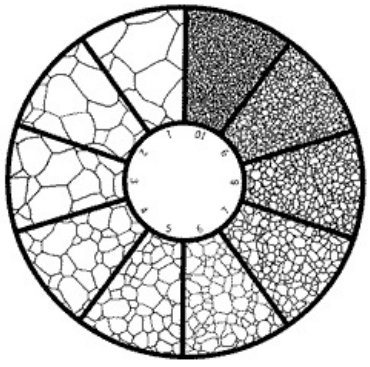
Ron Gray, *Northern Arizona University*

IN A SERIES OF ARTICLES IN 2008 AND 2009, Pam Grossman and colleagues examined professional practices outside of teaching to re-conceptualize professional learning in teaching (Grossman & McDonald, 2008; Grossman, Hammerness & McDonald, 2009). As a teacher educator, I found Grossman's work enlightening. She identified a major problem in teacher education: we too often focus merely on investigating effective instructional practices, but rarely provide opportunities for novice teachers to become competent at enacting these practices in the classroom. This has led scholars, largely in mathematics (Kazemi, Franke & Lampert, 2009) and science (Windschitl, Thompson, Braaten & Stroupe, 2012) education, to follow two general lines of inquiry: identifying so-called high-leverage practices (HLPs), and examining the 'problem of enactment' by investigating effective instructional cycles that allow novice teachers to enact practices in ever more authentic environments.

Let me set up my 'vexation' by first describing how the work of scholars engaged in the activities described above have informed my work with novice teachers. In my conception of professional teacher learning, novice teachers learn general and science-specific HLPs through a process of ***guided rehearsals and cycles of enactment***. In my preservice courses, I have focused on HLPs for ambitious science teaching (Windschitl *et al*., 2012) through these cycles – a repeated process that supports novice teachers unpacking aspects of practice by investigating, planning, and rehearsing instruction with coaching. Each step engages teachers in strategic analyses and teacher reflection. The attention to ambitious teaching allows us to develop a common language of practice, building community members' capacities and sense making. These HLPs are embedded within instructional routines that simultaneously maintain and mediate the complexity of teaching by simulating the multiple demands placed on teachers (such as attending to a clear goal, supporting individual and collective sense-making, and formatively assessing ideas to inform decision-making). Instructional routines bound and support teaching in ways that specify the ambitious instructional work and student content learning demands entailed in the routines. Through investigation and enactment cycles, novice teachers build knowledge, skills and sensibilities toward ambitious teaching in science.

With colleagues in mathematics and science education, I have been experimenting with different aspects of 'cycles of enactment.' We have found, for example, that these cycles are more effective through in-the-moment coaching and when coaches focus on a small number of practices at a time. The results of this work have been encouraging. Compared to previous iterations of the program, graduates have been able to enact far more complex and ambitious instruction as a result. While far from finished, I am now interested in shifting my focus from enactments to identifying the appropriate HLPs themselves.

What most vexes me at this point is the ***appropriate grain size*** of these HLPs. Multiple research groups have worked to identify HLPs. In the *Learning In, From, and For Teaching Practice* (LTP) project (http://sitemaker.umich.edu/ltp/home), Magdalene Lampert and colleagues have defined a mathematics-specific list of small grained HLPs including 'preparing for instruction toward a mathematical goal' and 'positioning students competently.' Deborah Ball's group at the University of Michigan (http://www.teachingworks.org/) has a general list that includes medium-grained practices such as 'leading a whole class discussion' and 'setting up and managing small group work.' Finally, in science education, Mark Windschitl and colleagues at the University of Washington (http://tools4teachingscience.org/) have identified science-specific practices at a large grain size including 'attending to students' initial and unfolding ideas' and 'making meaning of science phenomena' that occur over multiple days. Additionally, Doug Lemov (*Teaching Like A Champion)* has highlighted practices at a very small grain size but from a largely behaviorist perspective. What I find vexing as I draw from these different groups is the variability in grain size inherent in their identified practices. Conversations with other scholars similarly engaged in this work show me I am not alone. So I ask: What is the appropriate grain size of a HLP in science education? Are they the small, in-the-moment practices common in the mathematics education literature or do they take the form of large, lesson (or even multiple lesson) level practices that are more common in the science education literature?



Thinking about the Size and Scope of High-Leverage Practices in Novice Teacher Professional Learning

Ron Gray, *Northern Arizona University*

FOR MY VENTURE, I HAVE STARTED BY CREATING AN OVERARCHING FRAMEWORK to try out in my next series of methods courses. The framework stems from previous work with colleagues in mathematics education and has been adapted to my current context and made science-specific. It is meant to provide direction and cohesion throughout the varied courses and experiences of the 15-month graduate preservice program. Importantly, it also provides a common language for students and instructors to engage in dialogue about teaching at a more in-depth and specific level. I have identified three categories of decreasing grain size: instructional sequences (representing a grain size consistent with Windschitl *et al.*), instructional routines (representing a grain size consistent with Ball *et al.*), and instructional practices (representing a grain size consistent with the LTP project). Each level acts as a container for and target of the next. It is important to note the complexity of the term 'practice' (Lampert, 2009). In this context, I have chosen to use the term for the small grain size category and have chosen different terms (routines, sequences) for the larger grain size categories. I will provide a complete framework[1] at the conference, however examples include:

Instructional Sequences	Instructional Routines	Instructional Practices
• Eliciting students' initial hypotheses • Engaging students' sense making through purposeful activity	• Facilitating small and whole group discussions for a purpose • Facilitating effective openings and closures of lessons	• Representing student reasoning • Constructing and organizing public records • Eliciting and responding to student contributions

While far from complete, I believe the framework provides instructional targets along with common language to engage all members of the community. You can see that, starting from the right, not only does the grain size increase, but each category builds on the next. For example, the instructional practice of 'eliciting and responding to student contributions' happens in the moment. It, in combination with multiple other practices, is necessary to effectively 'facilitate small and whole group discussions for a purpose'. Multiple instructional routines make up an instructional sequence, such as 'eliciting student ideas to adapt instruction', which may take up to several days. These together lead toward the ultimate goal of designing instruction for all students to do rigorous academic work and to have equitable opportunities for learning. Taken together, this framework provides a structure from which to engage in Grossman's original call to action.

The next step, however, is less clear. My question remains: Which level in this framework (i.e., which grain size) should be the ultimate focus of professional learning for novice teachers? Put another way, which level provides the most 'leverage' in terms of enabling novice science teachers to enact ambitious science teaching? By focus I mean that the category is foregrounded for the students over the others. This would result in students describing their work in the classroom at that level. My initial 'hunch' is that a focus on the instructional routine level will provide the most leverage as it acts as a container in which to work on instructional practice and the raw material for work on instructional sequences.

[1] Note that the framework includes additional categories meant to provide a more complete view of ambitious science teaching. These include overarching Principles of High Quality Instruction and Principles of Learning to Teach as well as Instructional Design Strategies that include aspects planning such as identifying big ideas.

Envisioning Afterschool Science

Ann House
SRI International, Center for Technology in Learning

During a site visit to a rural afterschool program, we observed several science activities. One was of 16 kindergarteners and first graders about how plants grow. The day before the observation, the facilitator (who works as a classroom aide) had read a story to the group about how plants grow, and the children counted beans. This day's activity had students soak beans in water, while on the following day the children were scheduled to plant the beans in the clear plastic cups filled with potting soil.

The 20-minute activity we observed consisted of the facilitator passing out a small plastic cup and two beans to each student. She permitted two students at a time to go to the sink in the back of the classroom to fill their cups with water. Children selected to go to the sink were those who were most quiet and still. As students waited for everyone to fill their cup and return to their seat, they kept themselves occupied – most chatted with their friend seated nearby, three girls played "copycat" mimicking each other, and two boys played around pushing their friends' beans off their desks. The group was energetic, but did their best to "behave." Nonetheless, these boys were last to visit the sink. Once all the children had a cup containing some water and two beans, the facilitator went around to each participant's desk and wrote the name of each child on his/her cup. All the cups were then placed on a shelf in the classroom, ready for the next day's activity. The facilitator repeatedly reminded the students not to eat the beans.

At the conclusion of the session, the facilitator reminded her students of the book she read to them the day before about how plants grow, and turned to the page showing a seed in the ground. She asked, "Remember we saw in the book a seed in the ground? Does anyone remember the big word for when seed opens up?" Students didn't remember. She said the term is called, "germination" and showed them a picture of when the seed will start to grow and have roots. She then asked the children again, "What is the big word?" A girl replies, "Germany!"

In conclusion, the facilitator tells the students that tomorrow they will put their seeds in the soil. She then asked the children, "What do you think is coming first – the roots or the stem?" A few students quietly replied, "roots." The facilitator answers with a smile, "Well, we are going to see."

THIS VEXES ME. This session had plenty of things going for it: a planned series of lessons focused on the same topic; a warm relationship between facilitator and children; a program that regularly offered science activities; and a focus on a key science idea children can observe (and perhaps even care about). Yet this scene – and many others observed during our research on science learning opportunities in California publically-funded afterschool programs – reveal limitations in the science learning experiences provided.

It is widely shared among practitioners and other stakeholders involved in informal science and afterschool programs that science is a very strong match to informal learning environments like the program we visited. Rather than simply extending the school day, expanded learning programs provide a unique learning environment, with fewer institutional strictures and requirements, a prioritization of children's' interests and choices, a preference for modes of participation that are active and collaborative, and a goal of promoting positive relationships among children and between staff members and the children in their care.

As science education transitions from a driving mission of knowledge acquisition toward a focus on engaging in the practices of science, activities that involve asking questions, developing and using models, conducting investigations, interpreting data, constructing explanations, engaging in scientific arguments, and communicating information and findings have a natural fit in informal settings that emphasize youth development.

My vexation, then, is the *unrealized potential of science learning experiences in informal learning settings at scale*. There are well documented exemplary programs providing out-of-school time structured programs for youth. Yet these unique programs serve only a fraction of the 8.4 million children in the United States participating in after school programs each year *(Afterschool Alliance, 2009)*. So while science activities are commonly offered in afterschool programs, many programs are "not prepared to deliver high quality science programs," yielding "inconsistent quality across typical U.S. afterschool science learning" opportunities (Noam et al., 2010, p.3).

Envisioning Afterschool Science

Ann House
SRI International, Center for Technology in Learning

THE CHALLENGES INVOLVED IN ACHIEVING HIGH QUALITY SCIENCE LEARNING OPPORTUNITIES within the constraints in afterschool setting have been well documented and discussed – most notably, there is a lack of extended or flexible blocks of time, high staff turnover, little to no staff training or professional development, limited staff science knowledge, few supporting materials, and rare opportunity for activity planning time. Even so, our case studies offer evidence that, with the right support, youth development professionals can create powerful science experiences for children. At various moments in our site observations, we saw science activities that engaged children in exploring phenomena, collecting and analyzing data, asking questions, and discussing scientific concepts. Unfortunately, these moments were the exception.

The unrealized potential of afterschool science would be a much different challenge if we were just trying to enrich the science offerings at the site described above. But in California, there are more than 4,000 afterschool sites, and more than half of these report offering science once a month or more. How can a rich, engaging, expansive vision of science in informal learning settings be developed at scale?

For my venture, I'd like to engage the Crossroads community in conceiving the content and form of supports that could be provided to a facilitator like the one described above, in order to help create deeper science learning opportunities. I believe these should be tools that support the planning, implementation and reflection of science activities in quick and practical ways that build the capacity of staff and improve the science learning experiences of youth.

Because the afterschool setting is distinct in purpose and capacity from the formal school day, these supports must be creative and nimble. Ongoing professional development, pre-service programs, or strictly scripted curriculum do not fit in this context. We know from our analysis of the materials used in sites like the one illustrated above (Lundh, et. al. 2014), that afterschool staff use educative materials in distinct ways. Staff most often rely on step-by-step science activities drawn from books or the Internet. Some curriculum designed for afterschool is available, but this is not often used, and is not used to provide activities that continue or deepen through sequential experiences. So what will staff find appropriate, effective and even desirable to use?

I'd like to leverage the understanding of science educators at this meeting to explore ways to support afterschool staff with resources appropriate for their context. I'd like to ask the group for creative ideas for tools, such as smart phone apps or flash cards. And I'd like to explore the content that is most critical to provide in key moments – before, during and after the science activities they lead.

Although it starts with a vexing moment, this venture is very hopeful about the potential of afterschool science, and is designed to explore what combination of resources or tools can help staff build and deepen the science activities they lead. It is difficult to learn to facilitate inquiry-based or practice-centered science, and even more challenging for those who have never experienced it themselves in their schooling or had any training in how to offer such experiences. Offering the most appropriate and impactful resources to staff, then, has the potential to engage youth in science in at a large scale. And with the right supports, sessions like the one described above can provide richer experiences with beans, cups and germination for children.

Doing Right by Under-Represented Students: I have a bunch of data, what should I do with it?

Angela Johnson
St. Mary's College of Maryland

MY MACRO-VEXATION IS NOTHING NEW: The ongoing underrepresentation of women of all races and of Black, Latino and American Indian women among science majors and practicing scientists. But my micro-vexation is an enviable one: I have access to all sorts of really great data about STEM programs and departments which have higher-than-expected success at retaining and graduating under-represented students, and I don't quite know what to do with it all. This includes:

- ✓ a nice rich unanalyzed data set about several small programs at my little college which have had some success in retaining students like this;
- ✓ decades of graduation data in each of our STM departments (biology, chemistry, biochemistry, physics, math, CS; I've omitted the E in STEM because we don't offer engineering);
- ✓ my own observations of how some of these departments have radically altered their conceptions, in recent years, of what it means to teach a STM field, while others have not yet done so;
- ✓ the trust of many of the professors in these departments.

I have a sabbatical coming up in 2015-16, and I hope to use my incubator session to get feedback on what I've been thinking of doing with all these assets, research-wise. The relationship between my vexation and this year's focus on professional learning is pretty straightforward: If I can make good use of this data, I can help all of us find better ways to teach science and better ways to address the imbalance of who does science within our greater community.

Some of what I will do with this data is perfectly clear—I will crank out program evaluations and get them published in venues where interested people will find them. And in the evaluations, a major point I can make is that these programs are eminently sustainable; typically they cost the college either one course release for a professor or a few thousand dollars for a TA, per program, per semester—from an institutional perspective they are almost free. But I can also look at more interesting issues. Right now I'm thinking in particular of a potentially tricky question: Given that some of the STM departments at my institution started working on increasing graduation rates of students from under-represented groups much earlier than other departments, and have been (so far) much more successful at it, are there differences by department in the ways professors talk about students, about teaching, about learning? Are there differences in the ways the majors are organized, the expectations of students, the ways students are advised or supported, the kinds of required classes or assignments given to students? Finally, it's my sense that there might also be other, more subtle questions that could also be addressed with this data set, questions I'm missing right now.

First, the data:

When I started working at St. Mary's College (a small, public liberal arts college in rural Maryland), the prevailing view on campus seemed to be that because we had small classes and strong student-teacher relationships, we were a good place for students first-generation college students, Pell-eligible students, Black and Latino students. The then-president of the college had just made a promise to students from Cardozo High School in Washington, DC, that they could attend St. Mary's tuition-free. This was significant because those same students had just been abandoned by their benefactor; he had promised to pay their college tuition, but took a bad hit in the tech stock crash. Some of these students have done quite well for themselves since finishing college (one is now on the Baltimore City Council!) but their struggles, academically and socially, brought home to concerned faculty that a good liberal arts program is not enough. If a college wants to support students from historically under-served groups, we need to address their needs specifically.

Due to a happy coincidence, I came to St. Mary's from a program that had been very successful in doing just this, while a colleague in math had worked in an Emerging Scholars Program (ESP) as a grad student (for those not familiar with the ESP model, it consists of recitation sections for students enrolled in the gateway courses in STEM majors; the recitations are focused on challenge and enrichment, not remediation). Our combined expertise, together with a lot of goodwill and other equally rich backgrounds from other faculty members, led to the development of a series of support and enrichment programs in calculus, computer science, biology, chemistry and physics. I was the evaluator for the calculus and the computer science programs in their early

Angela Johnson
St. Mary's College of Maryland

years, and both have shown promising results. Over the same time period, some of our STM departments have become phenomenally successful at drawing in and graduating many more majors (in general and under-represented). Other STM departments have been undergoing change as well. One has begun to use learner-centered pedagogies and has developed an applied major. However, some STM departments have been slower to adopt approaches like this.

Besides graduation rates over time by department, I can lay hands on all sorts of magnificent quantitative data which would let me compare students who participate in each ESP program with a) similar contemporary students who don't participate, b) all contemporary students who don't participate, c) similar students who were at the college before the programs' existence, comparing at minimum their a) grades in the course, b) retention in STEM majors, c) graduation rates. I also have lots of pre-post affective data, and could gather more next year. I can also gather all kinds of qualitative data (by which I really mean interview data—I probably don't have time for participant observation) next year.

AS TO WHAT I AM ALREADY PLANNING TO WRITE ABOUT: Besides the evaluations, I would also like to write an article making the case for the value of ESP-type programs at liberal arts colleges and, if I can find data to support it, another article describing the the dispositions and practices of departments which are more successful with students from under-represented groups. I have been trying to frame some sort of meta-evaluation, too, looking at the success of the programs and departments as a whole and the conditions on campus which made that possible (not yet so clear as to how to make this of general interest).

Finally, I've been wondering whether I should also pursue theoretical questions about power, and privilege, and identity—about how power and authority get minced up and distributed (or hoarded); about who gets celebrated and who gets marginalized and, more important, how this happens; about cracks and fissures in the power structure, where leverage can be applied to change (to level) that structure. I've been very satisfied with my previous work on women of color studying science (and, later, pursuing science-based careers). Together with collaborators, I've used a theoretical framework grounded in ideas about identity, intersectionality and multiracial feminist theory which helped me make sense out of my informants' experiences and use those experiences to better understand both the constraints on them in science settings and the agency available to them in those settings. My feeling is that I can do the same with this current data set (especially since I have a year to gather qualitative data), but I'm not even sure what questions I want to ask.

Questions I would love to hash out in an incubator session:

- Is it politically non-astute (or even hurtful to my good colleagues) for me to compare (even if only to myself) the dispositions and practices of STM departments which have been more successful at graduating under-represented students with those which are only just starting this process? Ideas about how to do this without disaster or hurting people's feelings?
- If I can find a way to tactfully undertake this exploration, what should I be looking for? What research questions would frame this study effectively? What should I ask the professors about? What aspects of student experiences in each major should I be trying to capture? Should I interview students? (my sense is no, because I would have to interview so many—say five or more from each of five departments—or even ten per department, five underrepresented and five typical)
- What theoretical questions would it be possible for me to address using this data? Should I delve into the theoretically deeper stuff or just go for a straightforward story about STM, the liberal arts, and what it looks like to do a good job graduating students from under-represented groups?
- What else could I do with all this data?

These are the questions that are keeping me up at night right now, and, I hope, the question that folks at Crossroads can tackle on my behalf while I sit silent and mildly uncomfortable during my incubator session.

Acts of Learning

Adam Johnston
Weber State University, Ogden, UT

REFERRING TO EDUCATION AS "AN INVENTION" has been a useful rhetorical and conceptual tool for me. With preservice teachers, it's important for them to recognize that our educational system is constructed from both the materials society affords and by the constructors themselves. That is, education is not something predetermined and itself a boundary condition. It's something we can and should affect. We should re-invent it if it doesn't suit our purposes. This isn't only something we can do, it's our responsibility.

At the same time I take this stance, I've been operating from within the system for the last two decades as a teacher within a fairly narrow context. Granted, I don't settle for a status quo and I don't think I bow to all tradition, but I have a limited perspective. I've spent a long time thinking about my own teaching, staring at my own navel, and trying to improve my own practice. I haven't had the opportunity to step back and consider all of the possibilities of this invention.

By the time we assemble in Portland, I'll be underway with a year-long sabbatical project that is designed to address all this. Yet, I'm convinced that the process of figuring out what I'm doing will be ongoing. It's all part of an initial sabbatical proposal to my university that read like a practical joke. And yet everyone thought it was a good idea, that it was something I could do, and that it would be useful to myself and the wider community. Now, I have to make it happen.

The premise is that education is an invention and that we can learn from its varied possibilities and modes. Acts of teaching and learning take place in a wide variety of instances of classrooms and "traditional" educational settings. However we also readily acknowledge and value a variety of other arenas in which teaching and learning occur. No doubt, this extends to multiple strands within major education organizations, such as informal or free-choice learning, like museums; or professional development, as with professional organizations and workplace training. Each of these demonstrates nuanced differences, but we can find an even more impressive range of educational settings. I have begun looking further: How does one learn to choreograph dance? What is the apprenticeship process in a distillery? What are the goals and methodologies of a park ranger guiding tourists along a rocky outcrop? What's happening in the experience of a preschooler that mimics the life of a new graduate student? Is the process of personal development at a research conference (e.g., *Crossroads*, AERA) something that can be applied in a classroom? In general, what do other modes and goals of teaching and learning have to teach us about "traditional" educational settings?

It seems to me that the interesting questions lie both within the goals and the interactions of these learning contexts. As each of these contexts represents its own invention, each also presents a model from that could possibly apply to other contexts. Moreover, I'm convinced that traditional classroom education can shackle us to the extent that we do not recognize the invention of the system. If we recognize the value of other acts of learning as well as their methods, we may be able to apply these to other contexts, including my own classrooms. I may be able to learn something from the park ranger, the violin maker, and the choreographer that I can bring to my physics students, preservice teachers, and teaching colleagues.

AS NOTED ABOVE, BY THE TIME THIS SESSION REACHES ITS INCUBATION STAGE, I will have already stepped out onto the ledge of this project. In trying to describe my intentions, maybe it's useful to offer a bit about the impetus and inspiration. While in a moment of mid-career crisis and pre-sabbatical dreaming, I started to turn over the idea of simply taking a long walk in the woods. Or the desert. Although this wasn't too serious of a consideration, it did make me revel in the idea of Edward Abby's *Desert Solitaire*, in which the curmudgeon environmentalist spends a season observing the natural world and the stream of tourists flowing into Arches National Monument — which would soon become Arches National Park. My own experiences with national parks made me realize that I could learn a lot from spending an extended amount of time within such places. I could learn from both the space and the guides about how learning takes place in such a reserve, as well as ideas about curriculum development and teaching methodologies in that space.

That dream has morphed for many reasons. My daughters were a little apprehensive to live in that kind of seclusion. ("What will we do with [our cat]?!") More important, I've recognized that the National Park setting is but one of many possibilities to document acts of teaching and learning. This initial thinking has evolved and I've started to plan many novel (to me) experiences that I can place myself within.

Acts of Learning

Adam Johnston
Weber State University, Ogden, UT

My intent is to be something of a literary journalist — during my most romanticized and optimistic moments I like to picture John McPhee, veteran writer for *The New Yorker* and author of shelves full of books about everything from plate tectonics to oranges to transportation, as well as the people involved in all these endeavors. I envision embedding myself into multiple scenes over the course of a year. For each of these, I want to portray the goals of an educational experience and the methods involved. The kinds of experiences I've started to line up so far include: some work with a dance professor to understand more about how students learn and create choreography; work with a distiller, coffee roaster, and/or beer brewer to understand how someone is apprenticed into a profession; participation in a Massively Open Online Course (MOOC) in photography; participation in an experiential course in Yellowstone; interaction with youth and families in my Science in the Parks program; visits to other programs and spaces that some of you run in various corners of the country; and, of course the trips to work with National Park personnel. I also have some ongoing visits to elementary school classrooms planned, and I consider this very conference to be a venue to consider yet another collection of learning experiences. And I'm sure this will all get expanded and re-refined. I've started to wonder how to sit in on a band rehearsing to record a new album; and just as I was working on this proposal I learned about a violin-making school just down the road from where I live, intriguing me with a whole other possibility. The challenge isn't in finding possibilities, but in limiting them.

My goal is to capture the many varied stances, perspectives, and examples of what counts as teaching and learning. I know, for example, that what takes place in a MOOC and what takes place in dance must necessarily be different. The park ranger and the head brewer have different goals and different audiences. These are all inherently valuable, so I would like to interrogate these various modes and see how they compare with one another, but especially how they might inform my own teaching and classrooms in general.

My primary question in all this is regarding how to approach the project. My naive vision entails a notebook and pen at my lap as I sit in a corner and take in the phenomena of any given educational scene — a Jane Goodall of educational settings. Maybe I'll have an audio recorder and camera at hand as well. But I know that the equipment and my placement isn't enough. Moreover, I know I'm not the first person to want to write about education. While many write about education and its philosophical possibilities (e.g., Dewey, 1938), the inspiration behind its practice (Palmer, 1998), and even teaching memoirs (McCourt, 2005), I have yet to read anything resembling the kind of analysis I'm seeking. So, it only makes sense to create one for myself. It also makes me wary of what I might be getting into, what I'm missing, and what approach I should be taking.

I think there are a few key pieces others can help me with:

0. My initial premise is that this work is for me, but that I should hold myself accountable to others and open up to presenting this work in other contexts. Towards this end, I've created space to document the initial work: *firstdrafts.net*. I'd be delighted if others, Crossroads folks in particular, subscribed to this and kept me accountable. Are there other directions I should be taking?
1. I'm not actively looking for more settings, but I'm also open to suggestions. A helpful reviewer suggested that my notion of diverse settings is limited, but I also think I need to step into settings with which I'm at least somewhat familiar.
2. What should I be reading, either as examples of good writing, helpful descriptions of research methodology (phenomenology, community-based research, other journalism, etc.), or the completed book that has already documented these kinds of efforts?
3. Most important: How do I do this? Fundamentally, I can watch and listen, and then write it all down. But this is a unique context for me. I'm not sure who I need to be for this project. For now, I'm approaching this as a journalist rather than a researcher, but I'm open to thinking about other tools (either conceptual, like a research framework, or practical, like an audio recorder).

Wisdom, advice, warnings, and encouragement from others will be greatly appreciated. This project started from a bit of whimsy and self-imposed dare. (Incidentally, this is how Crossroads got its start as well.) I have just enough naiveté and ambition to believe that this could have importance beyond the entertainment that it has brought me while dreaming up the possibility.

Building Bridges between Science Teachers and Engineers

Meredith Kier
Howard University

ON THE DAY BEFORE THE CROSSROAD'S PROPOSAL IS DUE (after weeks of trying to find the words to articulate my vexation), I sit on the balcony of Howard University's Minor Hall looking over Northwestern D.C in search of my words. I'm hoping that this building inspires me like it has inspired so many others; the building where I sit was once the teaching college for the majority of African American elementary school teachers employed by D.C. schools from the 1870s through World War II. On the days that I walk up the steps of this building, I consistently think: how have I been lucky enough to be accepted into this world of such rich history? Further, how will I use this rich history and the innumerable resources around me in the District of Columbia to enact the mission of the School of Education and promote social justice, educational access, and opportunities for Black and underserved populations locally, nationally, and globally? This year, I have been searching for how I can use my strengths to impact the K-12 students in schools that now surround me. I look at my capacity for helping students in terms of my strengths (i.e., what I perceive that I do well) and what my surrounding population needs. At this juncture of my early career, I recognize myself as being good at engaging students, who are not engaged in school, and guiding them to connect science with their lives. Also, I see myself as very capable of forming trusting and long-lasting relationships with people from different backgrounds. I have used this strength in particular to initiate relationships with superintendents and principals in five of the largest urban districts in and around DC to better understand what role I could play in helping teachers engage the scientifically disengaged.

Through our meetings, both superintendents and principals have identified shared goals of helping their teachers to better incorporate engineering practices and engineering career information into science classrooms. Several superintendents also explained that implementation of these goals has not yet been attempted in the schools with the low science and mathematics scores, or with teachers who are teaching academic/standard-level classes. Together, we discussed building a mentoring network for teachers within these schools, their students, and local engineering stakeholders. We outlined goals of wanting to build teachers' awareness and confidence to teach the engineering practices outlined in the NGSS, and to help teachers and students understand what real engineers do. These conversations have led to my vexation: ***how do we foster a collaborative community of school administrators, classroom teachers, and engineering stakeholders focused on the implementation of NGSS engineering practices in all science classrooms?***

MY VENTURE MOVED FORWARD AS I BEGAN MAKING CONTACTS with minority and female engineers and engineering students to gauge their interest and motivation to work with secondary science teachers. Federal departments, universities, and industries were contacted and initial support of this venture was gained by 27 engineers in the Department of Defense, Environmental Protection Agency, Patent Trade Office, ASKII, Lockheed Martin, the FBI, GE Power and Water, Texas Instrument, and several chapters of the National Society of Black Engineers. Through these meetings, the professionals demonstrated their excitement about working to improve the implementation of the NGSS engineering practices. They agreed to collaborate with teachers to develop their engineering skills, and to engage in virtual lesson planning meetings to help teachers highlight engineering practices and real career-related skills. The support that I gained from engineers when "pitching" this idea was very encouraging and made me even more confident that I had the resources and networks to develop a unique professional development opportunity.

In a sense, I have placed the cart before the horse in establishing support from principals, teachers, and engineers before I have fully conceptualized the details of how science teachers and engineers can most effectively work together within the established science curriculum. At this time, I have access to two populations with entirely different skill sets: 40 science teachers in low performing schools in four urban districts AND engineers. I need to critically think about how to educate engineers on the reality of academic classrooms in urban high schools. Some of the questions that need to be addressed for the engineers are: What logistical limitations do teachers face (class size, access to supplies, time, etc.)? How well do teachers understand the engineering practices they are being asked to teach? What prior knowledge do students possess when they enter a science classroom? What supports to teachers receive from administrators, parents, and other community stakeholders? Additionally, I need to create a collaborative structure where

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engineers and teachers modify current science lesson/unit plans to include more design based tasks, model comparisons, etc.

Let's hypothetically consider this project taking place over the course of three years. I envision the following strategies could be used to achieve a goal of engaging students in lessons that explicitly connect science content to real-world engineering practices. In Year 1, teachers and engineers would meet in person for at least a week for both populations to understand the goal of the project. During this week, engineers would "get smarter" about the average urban public high school; they would be introduced to the dynamics of school districts, the pressures of standards-based tests, and the reality of classroom sizes/resources through discussions with teachers and administrators. Also, teacher educators would guide teachers and engineers to better understand definitions and through examples of the NGSS engineering practices. The engineers would be asked to review the NGSS engineering practices prior to the professional development meetings, and identify specific tasks from their day-to-day work experiences that fit into each practice. They could then share these experiences with the teachers as each practice is discussed in order to provide a clearer picture of the practical applications of each engineering practice. Teachers could then be arranged in subject-specific groups to review the engineering practices and document how, unit-by-unit, they are currently using the standards in their classrooms. Hopefully, the teachers would identify ways in which they are already implementing these practices, even if they have not been explicitly teaching them. The teachers would share this information with the team of engineers to further provide a shared understanding of the possibilities and limitations that they face in their science classrooms. The outcome of a summer professional development would be for each teacher to develop usable lesson plans with engineers that could be implemented in the upcoming school year.

During the school year, I would like to implement a co-planning model with ongoing collaboration and support between teachers and engineers, systematic professional development and feedback on lessons, ownership of content, and capacity for building on newly learned instructional routines (Fullan, 2001). One such model that I was recently introduced to was the Learning Studios model (developed by the National Commission on Teaching and America's Future; NCTAF) where middle school STEM teachers identify concepts that their students find conceptually difficult and work with both their colleagues in other disciplines and STEM professionals to develop projects that allow students to master these challenging concepts. Logistically because of the physical locations of teachers and engineers within this project, co-planning would be most feasible through online collaborative sessions where teachers and engineers would debrief and discuss how lessons developed during the summer worked in their classrooms and provide each other with recommendations for improvements and modifications. Also, teachers could use online co-planning time to build upon the expertise of individual engineers and develop new lessons. As the project continued, summer professional developments in Years 2 and 3 could include teacher educators and engineering educators modeling science lessons that use real-world engineering practices between teachers and engineers. They would continue to produce lesson plans, team teach, and plan how engineers might serve as guest speakers and role models for students. Together, teachers could develop a public online repository of lesson plans that could possibly be peer assessed.

I seek the guidance of my more experienced colleagues to help me "flesh out" the details and hurdles that I may encounter in implementing a project as this, specifically during the school year when I ask educators and engineers to co-plan science lessons. I look for guidance on how to ensure that engineers set reasonable expectations for teachers. Also, I ask, how can I facilitate a co-planning model that teachers do not feel overwhelmed with "extra" work? Are their current professional development models that have been successful in developing online collaborative structure between teachers and non-teachers? What are ideas for effective self and peer assessment of these lessons? I look forward to hearing the experiences that my colleagues may have in implementing similar professional development opportunities and for resources that may help me to better shape the vision for this project.

Creating a Healthy Ecosystem for Residents and Cooperating Teachers

Doug Larkin
Montclair State University, Montclair, NJ

MY VEXATION CONCERNS THE PREPARATION OF SCIENCE TEACHERS, and the various efforts in which I currently engage in this task. For the past four years, I have been working with the Newark-Montclair Urban Teacher Residency program, teaching the "methods" component of a field-based, one-year Masters certification program, and continuing this work of the residency as we expand the program into other districts.

My vexation has a few moving parts:

First is the question of recruiting and admitting individuals to teacher education and retaining them in the profession, a question that Luft and others have focused on in their research (e.g. Luft, Wong, & Semken, 2011). Two of our ten Noyce scholarships went unclaimed this year because we simply could not find enough people who wanted to be science teachers and commit to four years in a high-needs school. A subset of this issue is that most of the people we do recruit want to be biology teachers. While our schools definitely need biology teachers, I am wondering where all the physics and chemistry teachers are going to come from. I also just had the experience of having an individual finish the three years he "owed" the program as a chemistry teacher, and now he is leaving his job in Newark to go play guitar full-time. I think of all the hours I invested with him as a new teacher mentoring him and giving him feedback on his teaching. How can we attract teachers who will teach well and stay on?

Second is the question of finding cooperating teachers in the districts where we work. We have one Newark school that has been a very strong ally in all of our efforts, and they have hired many of our graduates. Other efforts to branch out have met with limited success. Currently in schools, teachers are under a great deal of pressure from all quarters. In particular there is increasing micro-management of teachers' work driven by standardized tests and evaluation systems, and the idea of taking on a student teacher seems to carry more potential hazards than benefits to many.

Third is the issue of program design, particularly with how the methods course curriculum interfaces with the classroom experiences of the residents and cooperating teachers, an important aspect of the design of the residency (Klein, Taylor, Onore, Strom, & Abrams, 2013). One trend that I have noticed in the residency is that the process of unit planning—which I still feel is an important skill for teachers to possess—is often one that our residents are not able to engage with in their sites because curricula are often already in place. This speaks to the broader issue of wishing to provide learning opportunities in methods that are both valuable and authentic across a wide variety of teaching contexts and disciplines.

The thread that ties all of these vexations together is a desire to prepare high-quality science teachers to work in our current schools, ready to teach for diversity and understanding and continue on as learners themselves, especially during those first all-important years as new teachers. Perhaps even more crucial however, is the pressing need to nurture the "ecosystem" in which the schools, teachers, and residents take on this work. I am increasingly convinced that cooperating teachers are the linchpin in all of these efforts, and building a community of committed individuals is the first step in strengthening this ecosystem.

WHILE THERE ARE A NUMBER OF ACTIONS THAT I AM CURRENTLY TAKING to try to address this set of vexations, I feel that a more coherent approach is needed. I am starting to perceive the broader outlines of the venture, and the conclusion that I am coming to is that what is necessary is the intentional fostering of a community of master science teachers.

In the past, both in New Jersey and Wisconsin, I have been part of "science sharing" groups, and am well-aware of the commitment needed to sustain such a community as well as the fundamental condition of ensuring that individual teachers derive a benefit from their participation. My hope would be that this community would be able to serve as a resource for teacher preparation, but would also be perceived as valuable for the participants themselves in their daily work. The learning community I envision would consist primarily of secondary science teachers who have an interest in supporting preservice and novice teachers, but

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beyond that I'm still struggling to think about what it might look like. There is an existing literature on professional learning communities in science education (Giglio, 2006; Lumpe, 2007; Nelson, 2009; Richmond & Manokore, 2011), and I would certainly draw upon this literature in designing this venture.

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

1.) Most successful communities have some task or mission at their core. ***How might I best frame this mission*** given the vexations described above? I have my own goals in terms of nurturing the ecosystem of cooperating teachers and schools, but I recognize that other issues will be important to teachers as well. Therefore, in the context of the current school environment—with all of its pressures—what are some tangible benefits that master science teachers might seek in a learning community?

2.) ***How might such a community be structured?*** I am hesitant to do something that does not include some face-to-face element, but I recognize the burden this creates as well.

3.) ***What are the practical elements that need to be considered*** in supporting and sustaining this community? For example, would it necessarily need to be part of a course or program that offered credits or a certificate? Would it need to be funded? Could it be self-sustaining?

4.) Perhaps most importantly, ***what might a group like this be able to do***? Clearly one of the values in a learning community is the sharing of teaching strategies and strengthening of content knowledge, but I think there are greater possibilities that connect with my vexations above. For example, I am thinking that this group could be used to create a short series of public service announcements, featuring science teachers in real situations doing the things they love in terms of teaching science. These could be videos poised to go viral, but at the very least could be used as a recruitment tool to plant the seed of the idea that one might wish to become a science teacher. Personally, I have never seen an ad for science teaching, though I remember clearly the Peace Corps ads from my childhood, which I would love to mimic in style and tone. What other affordances would this group have?

5.) Finally, ***how might teachers be recruited*** into such a community?

The larger venture would somehow entail identifying and sustaining a larger group of master teachers who could serve as mentors but also derive a clear benefit from the partnership in a way that is recognizable and does not work against them in the wider context of the work. I really want to rethink what it means to be a "cooperating teacher," and what the real purpose of fieldwork is in terms of the long arc of teacher growth, creating a much longer-term relationship that allows for greater growth as a teacher to occur.

How to Get Invited to the Prom: Self-Study and its Place in Science Education Research

Megan Leider
St. Rita of Cascia High School, Chicago

AS A HIGH SCHOOL TEACHER, THE PROM REPRESENTS MANY THINGS. It marks the end of the school year, graduation, and for many of my students, constant stress. They start planning, many times, before winter break. They need to find a date, ask the date in a clever but not too enthusiastic manner, then plan the post-prom activities. These plans usually involve going to someone's cabin in Indiana to underage drink until someone's parents find out and cancel the entire trip. Despite being decades removed from my prom, I can be swept up in the infectious excitement of it all.

I find that I still get that prom feeling, but now my prom does not involve wearing a hunter green dress that my mom made with velvet flats, nor does it include my date who was a good 4 inches shorter than I was. Prom is about belonging and feeling accepted. Whether it is getting asked by the guy who still wears a batman cape on dress down days to taking group photos with your friends, prom is important because it gives students on the verge of adulthood one last feeling of togetherness and comfort before real life sets in and they all travel down their different paths.

There are still events and places in which I would like to be included. Currently, my prom is the science education research community. Granted, I am not sure I would like to slow dance to "In Your Eyes" with the research community or drink Bud Light Lime with them at their parents' Indiana cabin. I do know that I want to feel like I belong at the party. I have been a classroom teacher for thirteen years and a researcher for over three. I understand I am new and that I have so much more to learn. Just as I fell in love with teaching so many years ago, I have recently fallen in love with researching, especially with my research method of choice: self-study.

A few years back, I was introduced to self-study. My colleague and friend Elizabeth Coleman and I turned the researcher lens on ourselves and conducted a self-study of our beliefs, values, and experiences as we designed and implemented a new action research curriculum in my freshmen science course. This self-study gave me the confidence to take risks in the classroom, to be more present to my students, and to become a better advocate for my students and their needs in the science classroom. The process of self-study was transformative.

Elizabeth and I spent many months creating a research plan; collecting and analyzing our data; and forming thoughtful and valid conclusions. Our research questions required us to take a systematic and thorough look at our practice. We audio taped our conversations regarding the design and implementation of this new curriculum as well as challenged ourselves through written journals to look deeper into who we were in the classroom and who we wanted to be. We also asked a professor of ours to periodically review our work and to question our decisions as researchers to ensure that our study was rigorous and meaningful.

Since this experience was so powerful, I thought other practitioners naturally would want to engage in self-study. I felt that our research gave teachers a voice and could empower them through reflection, so it only made sense that other researchers might want to read our story of how we were able to fuse teaching with researching to become stronger practitioners.

I sent the manuscript detailing our story and our findings to science education journal after science education journal. And in return I got rejection after rejection. I am talking rejection not revise and resubmit. Being the sassy go-getters that Elizabeth and I are, we took the feedback and attempted to make sense of it. Unfortunately we found very little overlap in the reviewers' comments. Some suggested that we talk more about the students despite the fact that we mention in the beginning that we are researching ourselves and not our students. One reviewer wanted us to include a list of codes we used in our analysis (because that is totally normal) while another wanted to know if the curriculum and its implementation was "any good."

It became clear to me that I was not communicating the benefit of in-service teachers conducting self-studies and how this research contributes to knowledge generation, even if our experiences mirror those documented in other research studies. This obstacle has become that much bigger and much scarier now as I conduct a

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self-study as part of my dissertation research. I want to feel as though I can still attend my current version of prom or at least the Indiana cabin after party while staying true to who I am as a teacher-researcher.

FOR MY VENTURE I AM SEEKING CLARITY AND DIRECTION. As I stated earlier, I am essentially a toddler researcher. I can walk on my own and communicate using full sentences, but I also know that I have so much more to learn and to experience. I am hoping that I could receive guidance on how to get me and my self-studies invited to the prom.

First, I would argue that self-studies are misunderstood. Attention to validity, quality and triangulation are first and foremost a priority. Self-study is not just navel gazing and I can state with confidence and certainty that I have taken zero selfies as part of my self-study research. As a classroom teacher, self-study is about becoming a better teacher by systematically looking at my practice – at who I am in the classroom while engaging my students in science.

Self-study requires more than just sitting at my desk at 2:30 in the afternoon and thinking about what went wrong or right during the day. It requires intense written reflection, audio journaling while on my way home, and digging up old lesson plans for analysis. Self-study reminded me why I wanted to be a science teacher and reignited my passion for science teaching and learning. I am living proof that self-study can help students by helping teachers.

Second, what are ways in which I can tailor my self-study to meet the demands of the science education research community? Let me clarify. I do not see myself as Sandy (aka Olivia Newton-John) in the greatest movie of all time, Grease. I have zero intention of changing into tight pants and to start smoking just to become accepted. In this case, I am definitely Rizzo (aka Betty Rizzo aka Stockard Channing) – well-meaning but misunderstood. I am not looking to change who I am or what I believe as a teacher-researcher. Rather, I am looking to better understand the research community and to learn the rules of the game in hopes of finding my place. The AERA Self-Study SIG has been instrumental in furthering my understanding and passion for self-study. But I am a science teacher-researcher. It is important to me that I feel as though I belong in the science education research community. Many of my teacher colleagues do not feel connected to the world of science education research. Self-study and other forms of practitioner inquiry could assist in narrowing this divide.

The solution to these above quandaries could actually be found right here within the Crossroads model. I was first introduced to Crossroads as a way to share ideas and to build community with those who deeply care about science education in a non-competitive and, dare I say, fun manner. As science educators and researchers, it should be assumed that we all want students to have the best science education experiences possible. If we all have this same goal, then we should be able to form a constructive dialogue, right? I would like to spend my time at this year's Crossroads exploring the following questions:

- ***How could the Crossroads model of sharing ideas and providing meaningful feedback create a sense of community amongst those pursuing self-study in the science education research world?***
- ***How can the messages within these research communities be brought to those outside so that others can be educated on self-study and other less-valued forms of research?***

I have no plans or desires to become prom queen. But I have an arsenal of entertaining dance moves and I like to think of myself as a party accelerator. I think the prom would benefit from my attendance. Now I just need to get through the line of chaperones and pass the Breathalyzer.

Science Education Reform: Just Old Wine in a New Bottle?

Karen Lionberger
University of Georgia

THERE I STOOD "BRIGHT-EYED AND BUSHY TAILED", to quote an oft used idiom by my grandmother, in front of approximately 40 Advanced Placement (AP) science teachers who were awaiting the start of a professional development workshop on engaging students in science practices through inquiry-based investigations. As I double-checked computer connections to the LCD before I began the workshop, a veteran teacher calmly strolls up and informs me that:

> *…if you stay in education long enough you'll hear these things [reform efforts] come around every few years but just repackaged to make us think it is something new that will "work" this time. I heard it from you guys [policy makers] in the 80's and again in the late 90's and now again with the new AP curriculum and the Next Generation Science Standards. If you ask me, it is just old wine in a new bottle, so good luck.*

Did you hear that? That was the sound of my bubble of enthusiasm bursting from one sharp blow. My eyes certainly became less bright as they clouded over with a fleeting vision of a young Charles Eliot, prior to the Committee of Ten, also standing before a crowd passionately calling for a reform in how we approach science education during his inaugural address at Harvard. For a brief moment, even I started to wonder if we've really made so little progress that I'm doing nothing more than espousing ideas that have been recycled throughout the course and history of science education.

I happen to disagree with this veteran teacher's description of reform as mere "repackaging" and instead think that over time the collective efforts of educators and research and policy reform communities have resulted in cumulative "progress" across the vast and varied landscape of science education. I have had more than my fair share of angry teachers who have verbally and colorfully expressed their distress over curriculum changes, be it as a high school department head implementing new district standards or now through my curriculum and professional development work that results in workshops and conference presentations about current reform efforts. So why did this one teacher's comments impact me so strongly? After some reflection, I've realized that it was a culmination of concerns that have been brewing over the last two years about whether or not meaningful change will actually take root in science classrooms if consistently reform efforts never garner support from the change agents themselves –teachers.

The new framework and standards take a brilliant step forward in articulating what it truly means to "know" in the context of science, informed by a strong evidence-base in cognitive sciences, through articulation of "three-dimensional science learning"– integration of conceptual understanding, cross-cutting concepts, and disciplinary practices. However, the same characterizations I use to paint its brilliance also create an inescapable need for innovative, research-based teacher support that can deftly unpack the complex framework in ways that value and apply to teachers' practices. In light of this complexity, and given how difficult it can be to implement sustained learning opportunities for teachers, I'm worried about how far the needle of change will actually move in science education. Thus, my vexation is really two-dimensional:

> **Shared Belief** - If we expect any type of meaningful change to occur in science classrooms then we must first garner a shared belief that the current reform effort is necessary and beneficial across the actual change agents – the teachers. As veteran teachers will gladly point out, they are exposed to numerous "reform efforts" throughout their careers and often in a non-collaborative, top-down manner, through complex curriculum documents flavored with edu-jargon that ultimate make teachers feel disenfranchised from the effort.
>
> **Supporting Capacity** – In this case I am referring to capacity as a necessary, mechanistic function during the implementation of the new standards. The recent NRC report *Developing Assessments for the Next Generation Science Standards* (2014), recommends a "bottom-up" approach for the first phase of developing assessment for the new standards. Specifically, they recommend that these assessments be integrated into classroom instruction and then go through several iterations of design-based research to modify them accordingly. However, teachers typically are afforded limited time and support for collaborating, designing, and reflecting on assessing student knowledge.

Science Education Reform: Just Old Wine in a New Bottle?

Karen Lionberger
University of Georgia

THE VENTURE INCLUDES A DESIRE TO ENVISION AN APPROACH TO BOTH PROFESSIONAL DEVELOPMENT and educative curriculum design that values teachers' voices and practical knowledge as a means to building both capacity and a shared vision for change. Realizing the inherent complexity in assessing the interconnected nature of students' knowledge with regard to disciplinary core ideas and crosscutting concepts in the context of the science practices, we need to define novel professional learning opportunities and teacher resources. This venture intends to provide professional learning opportunities and educative curriculum materials that work together to engender the shared belief in the *need* for change while also building support for the roles required of teachers if this science education reform effort is to have any lasting impact.

In prior professional development workshops, I have designed my approach based on the assumption that most teachers are open to new ideas for instructional and formative assessment opportunities that build students' understanding of how scientific knowledge is constructed slowly over time. I fully extend an analogous assumption to describe the progression of knowledge in educational research. Therefore, I have been working from the expectation that there is a shared belief across educators that reform is a natural byproduct of that progression, and thereby new approaches to instruction and assessment are exciting and welcomed in the classroom. I think one of the reasons the veteran teacher's words elicited such a fervent response from me was because it defined a moment where I finally realized that this "shared enthusiasm" did not fully exist, and his use of the words "you guys" made clear a demarcation that had not been completely obvious to me before: we were not teammates in this reform effort because I represented the top-down, policy implementation faction in the system of change.

When I was a teacher in the classroom it felt easy to rally people towards system-wide change as I was one of the teammates they trusted. As a science department head, while harder, I still felt I could fuel a desire within our department to implement changes. Although maybe driven more from a coach-like influence, change was possible since I was still viewed as being on the same team. Not being in the classroom, I'm realizing that during professional development, and discussions on the changes with AP or NGSS, teachers view me more as the umpire implementing "top-down" rules (policy). No one cheers for the umpires when they take the field. Consequently, I need to rethink my approach to the development of the professional learning opportunities and resources aimed at supporting teachers' implementation of the new standards. It should be informed by the understanding that the "need for change" is not always shared, may be driven by contrasting forces, and that those produce barriers to change.

Currently, the vision of the venture includes first gaining better insight into teachers' current beliefs about the new science standards, and particularly the science practices, in a way that identify barriers to creating a shared enthusiasm for change. This understanding will be used to inform development of educative curriculum materials and corollary professional development whose tone and language speak directly *to* the teacher as a means of valuing their voice and cultural fund of knowledge as the change agents in reform. Realizing that the venture's breadth of focus could risk teachers' motivation for enactment, we will focus on supporting teacher thinking in three main areas: supporting evidence-based reasoning, increasing student engagement through higher-level classroom discourse, and metacognitive reflection on assessing those science practices. I'm looking for guidance, thoughts, and possibly lessons learned, about garnering a shared belief in the process and progression of science education reform and how best to craft support for teacher thinking, in these three main areas, through curriculum and professional development that works from a lens that values teachers as active designers of the enacted curriculum in the science classroom.

Conceptual Fidelity or Contextual Classroom Adaptation: Appropriation from Professional Learning

Max Longhurst, *Utah State University*

Can professional learning designs be created that maintain conceptual fidelity while allowing for practical and acceptable adaptation in classroom contexts?

SCIENCE EDUCATION REFORM EFFORTS BEING CONSIDERED NATIONALLY support a spectrum of goals intended to positively impact classroom instruction and student achievement. In this landscape of reform, classroom educators are faced with the challenge of creating learning environments that fundamentally differ from the classrooms they personally experienced. As a science education community, we are developing more refined understandings of the instructional principles and practices that hold the promise of developing learners who possess the scientifically minded qualities needed in society. Thus, the challenge for educators is to apply concepts and practices of science instruction that may be new or foreign to their current practice within an existing paradigm of professional learning.

The underlying premise of professional development (PD) is that if teachers are better prepared then those efforts will translate to improved instructional practices, which in turn, results in increased student learning outcomes (Banilower, Heck, & Weiss, 2007). In fact, this link between what a teacher does and what a student learns is the underlying purpose to all formal pre-service and in-service teacher education programs (Shymansky, Wang, Annetta, Yore, & Everett 2012). How can teachers who participate in professional learning implement at optimal levels while also having the capacity to adapt to unique classroom settings. In multiple settings, science teachers can be observed adopting, adapting, or regularly discarding conceptual ideas and instructional practices specified by PD providers. Professional learning that uses proven teaching strategies and even provides effective curriculum may not be enough to ensure acceptable classroom enactment. In order to achieve the positive impact of reform goals, educators need to understand how teachers appropriate new instruction.

Often PD targets the training of teachers to uniformly enact procedures in an effort to match expert models of delivery. Focusing on delivery **of** practice can devalue the need for conceptual understanding **for** practice. However, even with a focus on clearly defined instructional concepts and practices teachers enact professional learning with implementation ranging from full adoption to complete abandonment. Herein lies a dilemma. Adherence measures appear to implicitly, if not overtly, require script-like fidelity to the curriculum or the expert model. However, attempting to achieve ideal curriculum fidelity may limit acceptable contextual adaptation, a quality critical if teachers are going to effectively appropriate new instruction practice.

For the purpose of understanding my vexation, educational ***appropriation*** can best be understood as a continuum of how an educator acquires and implements both practical and conceptual aspects of learning from professional development within local context. To clarify, I would like to explore two concerns, 1) How can PD providers measure, understand, recognize, and offer learning opportunities for practitioners to personally assemble new pedagogy within their classrooms that capitalize on expertise, context, and resources? 2) Can we identify indicators of conceptual and practical appropriation that distinguish the quality of individual classroom implementation of instruction? Identifying what aids teachers in appropriating new concepts of instruction and implementation practice seems to be a critical aspect to reaching the goals of professional learning.

From my current work using activity theory as a theoretical framework and appropriation literature, it appears that conceptual and practical tools are components that enable teachers to adopt, use, and modify pedagogical practices following professional learning (Grossman, Smagorinsky, & Valencia, 1999; Yamagata-Lynch & Haudenschild, 2006). The process of appropriation uses educator's understanding of educational tools in both conceptual and practical ways in order to implement those practices in the most sophisticated approaches. However, traditional PD has been viewed in terms of teachers dutifully implementing the ideas of others, which is often described in terms of fidelity of implementation (FOI) limiting the adaptation for contextual variation (van Driel, Beijaard, & Verloop, 2001). Fidelity measures can be helpful as they provide quantifiable data regarding the implementation of new practice. However, when considering the need for educators to have both a conceptual and a practical disposition to new teaching practice, simply looking at fidelity may exclude helpful insights regarding quality appropriation of instructional practice.

Conceptual Fidelity or Contextual Classroom Adaptation: Appropriation from Professional Learning

Max Longhurst, *Utah State University*

SCHOOL DISTRICT DRIVEN PROFESSIONAL DEVELOPMENT HAS HISTORICALLY BEEN THE VEHICLE for improving instructional practice through practices such as workshops and training sessions. Constructing the objectives and goals of professional learning is clearly a critical aspect in the development process, yet this key step should not be done in isolation. Developing approaches to PD leadership that reduce the hierarchy between content experts (science education researchers) and practicing experts (classroom teachers) may provide pragmatic and theoretical discourse that enable teachers to acquire both conceptual and practical ways of appropriating instructional models (Penile & Gallagher, 2009; Shymansky et al., 2012; Van Duzor, 2011). The role of the expert has been to disseminate proven strategies or practices with the intent that the participant would obediently follow the template and thereby achieve greater student engagement and improve learning outcomes. Reconceptualizing the role of the expert has promise. In my current research connected to a NSF DRK-12 project, my colleagues and I have discovered that although we were positioned to be experts with a group of 8th grade science teachers, we were able to develop conceptual dialogue around unpolished versions of learning modules. With a focus on the conceptual principles, it may be possible to develop greater appropriation of these principles than simply targeting the teaching practices modeled during the professional learning experience. By focusing on conceptual principles as science educators, we may identify practical tools through discourse and negotiation with school-based leadership that lead to curriculum resources more easily accepted by classroom teachers. This process of development values conceptual principles while equally recognizing the need for unique application of practical tools within a classroom context. Combining science education researchers' and school level educators' expertise within leadership delivery groups could be pivotal when crafting professional learning (van Driel et al., 2001).

I hope to learn more about what influences teachers' change in practice and how they appropriate new pedagogy as I conduct my dissertation research. My intent is to select teachers who participated in a professional learning experience and whose students' exhibit gains in achievement greater than their peers. After selecting participating teachers, I will make classroom observations with paired interviews to connect conceptual knowledge with classroom practice. Using this format will hopefully allow me to identify attributes from professional learning that influence motivation to appropriate instructional practices. During these interactions I hope to involve participating teachers in articulating their personal appropriation trajectory to be used in differentiating professional learning that mirrors classroom instruction of students. I believe that as we recognize indicators of appropriation, differentiated methods of professional learning will emerge. Regularly teachers differentiate instruction in classrooms. It is time to consider differentiated instruction models for adult learners.

As indicated previously, there continues to be challenges of quantifying the quality of professional learning implementation. During the observations and interview process, described above, I hope to identify modifications teachers make in order to recognize indicators of adaptation made by teachers that constitute acceptable mutations of the PD. By doing this, we may begin to recognize indicators of acceptable appropriation that can be encouraged by professional learning providers.

Developing and Applying a Model of Ambitious Assessment in Science Classrooms

Edward G. Lyon, *Arizona State University*

ASSESSMENT (THAT IS, ELICITING, INTERPRETING AND USING EVIDENCE OF STUDENT LEARNING) serves more than an evaluative role at the classroom level; it serves an instructional role by: (1) letting the teacher and the students know "where they are at" in relation to well-defined learning goals and criteria for success, and by (2) subsequently deciding upon "next steps" to help students meet learning goals via targeted feedback and modified instruction. Researchers have taken the theoretical insights of this formative use of assessment and suggested assessment knowledge and practices that teachers would need to support science learning in the classroom. For example, Abell and Siegel (2011) proposed four categories: (1) assessment purposes, (2) what to assess, (3) assessment strategies, and (4) interpretation and action taking. Like others, they argue that teachers' "overarching ideas and beliefs" about assessment (p. 212) are central to guide decisions in the science classroom.

I am passionate about understanding what core formative assessment practices will be particularly useful for supporting rigorous and equitable science learning for a growing subgroup of students – English learners. English learners benefit substantially from science teaching that integrates inquiry-based science learning with language/literacy development (Lee, Maerten-Rivera, Penfield, LeRoy, & Secada, 2008; Stoddart, Pinal, Latzke, & Canaday, 2002). Simultaneously, research on the assessment of English learners has identified linguistic and cultural features of assessment that may interfere with interpretation of what students actually know and can do in science (Abedi & Lord, 2001; Solano-Flores & Nelson-Barber, 2001). I see a potential problematic conflict that needs resolving between these two lines of inquiry — reflecting a sort of "crossroads" for formative assessment research and practice. On one hand, ELs benefit from widespread interaction with others and language use, such as engaging in argument from evidence. On the other hand, does assessing with multiple uses of language preclude the teacher from really knowing where ELs are in meeting learning goals? Formative assessment seamlessly integrates instruction with assessment – thus, it appears we should draw on both lines of inquiry, instead of choosing one, but how?

I have previously developed the construct of "assessment expertise" through three interrelated dimensions: ***Designing Assessment, Using Assessment,*** and ***Addressing Sociocultural Influences in Assessment*** (Lyon, 2013). This conceptual model aimed to articulate a progression of moving from novice to expert while planning to assess science in linguistically diverse classrooms. The dimensions draw on sociocultural views of assessment, which have been rarely used in classroom assessment literature. The table below displays the "ambitious" level of the developed Assessment in Science Classroom Observation Rubric (or ASC-OR).

ASSESSMENT DESIGN	
Assessment Activity	*Sustained* **open-ended activities** that integrates core science ideas with scientific/engineering practices and are *contextualized* to real-world contexts.
Assessment Coherence	Assessment activity **fully aligned** with both a specific learning objective **and** specific criteria that reflect varying proficiency levels.
ASSESSMENT USE	
Communicating Expectations	T communicates what Ss are expected to learn and makes *clear connections* to expectations for meeting the learning objective. T and Ss *discuss* or co-construct expectations.
Eliciting, Recognizing, and On-the-fly Acting	T elicits Ss' prior **and** on-going conceptions about science ideas through probing resulting in sustained discussion with *some* S-S talk. T acts upon key responses.
Gathering, Interpreting, and Planned Acting	T interprets and provides feedback on S work targeting scientific thinking **AND** promotes S reflection of *changes* in their learning. A series of assessments used collectively to modify future lessons to address individual S conceptions.
ADDRESSING SOCIOCULTURAL INFLUENCES IN ASSESSMENT	
Scaffolding Language Demands	T addresses sociocultural influences by s*caffolding* language **AND** designing and using assessment activity so that Ss' contributions are *meaningfully* integrated.
Promoting Literacy	Opportunities for Ss to engage in authentic literacy tasks with appropriate expectations and scaffolding for the assessment's purpose. S work is interpreted for conceptual understanding *and* their comprehension of and communication with language.

Developing and Applying a Model of Ambitious Assessment in Science Classrooms

Edward G. Lyon, *Arizona State University*

THE VEXATION DESCRIBED ABOVE LED ME TO VENTURE into a research agenda to develop and apply a well-supported model of rigorous and equitable – or ambitious (Windschitl, Thompson, Braaten & Stroupe, 2013) – assessment in secondary science classrooms. The model would include…

a) theoretical implementation levels of ambitious assessment (modeled in a rubric),
b) clear examples of the implementation levels in practice (modeled in vignettes/exemplars), and
c) a clear and predictive explanation of how the implemented assessment practices lead to desired student outcomes.

Next, I describe a current study, "Ambitious Assessment in Science Classroom" to focus on items (a) and (b) above to eventually arrive at item (c).

Part I: Piloting. I first piloted an observation protocol (rubric + lesson debrief), survey, and interview protocol with seven secondary science teachers. Resulting revisions to instruments increased construct clarity, reliability, and generated a preliminary coding scheme. The following year, I piloted the revised instruments with an expanded (N = 15) group of secondary science teachers in a pre/post structure. First, teachers were surveyed/interviewed and then observed three times. I provided the teachers with twenty hours of professional development, orientating them toward principles of formative assessment and ways to consider sociocultural influences while assessing (e.g., attending to language demands, promoting literacy in science). Teachers were observed, surveyed, and interviewed after the professional development to understand successes and challenges uptaking and applying ambitious assessment practices.

Part II: Design-based Assessment Plan. Three teachers participating in Part I will work closely with each other and me from October 2014 to February 2015 to refine their assessment practices during a selected curricular unit to support learning and language development for English learners. Teachers will view and reflect on video clips of their teaching and assessment artifacts (gathered from the previous year) and discuss ways to enhance practices to better reflect the "ambitious level" of implementation. The hope is that the study will lead to new insights about particular formative assessment practices and the process by which teachers plan how they assess science in linguistically diverse classrooms. Coupled with student survey and focal student interviews, tentative links can be drawn between assessment practices and desired student outcomes.

My primary goal at Crossroads is to reflect on how both parts to the study can advance a model of ambitious assessment. In particular, I would like more insight into the following:

- How do I use actual observations of science teachers to refine and advance the ASC-OR conceptually and to yield valid interpretation of practice?
- How can I use the collaboration and resulting products and practices from Part II to further advance how I conceptualize and explain the effectiveness of ambitious assessment practices? What student outcomes and data sources might be useful to support this explanation?

I would engage Crossroad participants by presenting the observation rubric and vignettes from observed teaching as a way to match "theoretical" levels of implementation to "actual" implementation. Finally, I would describe how I have used the rubric along with supporting documents to collect and analyze data on the teachers' assessment practices – and inquiry about modified/alternative ways to study these practices.

Overall, by embarking on this venture, I aim to provide deep insight into the vexing problem of how formative assessment can truly serve its instructional role in linguistically diverse classrooms.

my notes

Leveraging a Grant-Funded Science Education Faculty Professional Development Academy to Develop a Statewide Community of Practice

Juanita Jo Matkins, *College of William & Mary* +
Jacqueline McDonnough, *Virginia Commonwealth University*

IN VIRGINIA, THERE ARE OVER FORTY BRICK AND MORTAR INSTITUTIONS OF HIGHER EDUCATION. At least 30 of these provide teacher education programs leading to licensure of elementary, middle and secondary teachers. In most of these institutions the science education courses and programs are delivered either by adjunct faculty, faculty in science departments, science education faculty who are the sole voice for science education in their institution, or some combination of these. These variations in professional status lead to parallel variance in outcomes, thus leading to K-12 science teacher educators with inconsistent and out of date understanding and application of research-based practices. In addition, individuals who are the sole K-12 science teacher educator at their institution are usually not embedded in a research or science educator community of practice or practice community.

The phrase "community of practice" applies where persons work together to develop a common product (Wenger, 1999), a somewhat different perspective from a "practice community" where persons of similar backgrounds or professions work together toward independent purposes (Settlage & Johnston, 2008). The profile of Virginia science educators recommends a structure that supports both the development of community of practice, where educators together design certain products to be used in their individual institutions but also a practice community designing products and approaches intended for their individual use without any intention of transference to their peers at other institutions. The Virginia Initiative for Science Teaching and Achievement (VISTA), an i3 partnership led by Co-PIs at four universities in Virginia, includes a continuum of four major activities: (1) an elementary science teacher institute, (2) coursework for new middle/secondary science teachers, (3) an academy for school district science coordinators, and (4) a Science Education Faculty Academy (SEFA). The SEFA brings faculty together for a week in May, after college graduations are over, for professional development. A key goal of the SEFA is building a community of practice/practice community that will endure beyond the grant. The SEFA starts with a one-day ***Science Education at the Crossroads in Virginia*** conference, complete with Vexations and Ventures. The next four days are filled with sessions on various topics considered useful for the science educator. VISTA provides participants with a $2000 stipend and covers travel expenses. In addition, SEFA participants receive travel and registration for the fall conference of the Virginia Science Education Leadership Association (VSELA).

The total number of individual participants in V&V sessions at the Science Education Faculty Academy (SEFA) in Virginia to this date is 40, with seven participants returning for multiple years of the SEFA, as space permitted. The number of papers discussed in the V&V sessions (listed below) includes papers presented by participants and also by VISTA faculty, with V&V and participant totals each year at:

	Attendance	SEFA V&V Theme
Year 1, 2011	7 participants + 5 VISTA faculty and staff	*Inquiry*
Year 2, 2012	11 (includes 4 returning participants) + 5	*Nature of Science*
Year 3, 2013	13 (3 returnees) + 3	*Social Justice*
Year 4, 2014	16 (1 returnee) + 3	*Standardized Testing*

SEFA leaders and other VISTA staff coordinate the reviews of the V&V papers with each reviewed by two editors and returned to authors for revision prior to the academy. Just as at the national Crossroads conference, final papers are printed in a bound copy for distribution on-site. An e-copy of the booklet is emailed at least three days before the SEFA, with the request that the participants read the papers prior to the first day.

We have experienced varying levels of comfort from the SEFA faculty about these V&V papers, and have found that several strategies assisted participants in writing their V&V papers. These included sending examples of V&V papers from previous years (the first year we used V&V papers from the Settlage & Johnston conferences, establishing a theme for the papers, and setting a timeline that allowed time for writing and editing the papers while also considering school calendars). The participants' responses to the themes revealed aspects of understandings and misunderstandings that shaped subsequent conversations in the SEFA. There was a wide range of approaches to a V&V on nature of science in 2012. In 2013, the theme of "social justice" required many back-and-forth emails with participants who inquired what that was, exactly, and could we please let them know if their idea for a V&V was acceptable. We had no such queries in 2014, nor did we see a wide range of approaches to the V&V's about standardized testing. The majority of the V&V's in 2014 were focused on Virginia's K-12 end of course Standards of Learning tests for science, and the negative affects that we were seeing across Virginia. Though there has been

some discussion about moving the V&V sessions to later in the SEFA, the leadership team decided that the V&V sessions themselves were such a powerful community building activity that these sessions were most effective at the beginning of the weeklong academy.

The rest of the SEFA week was devoted to professional development on other issues in science education and on focal topics. In most cases the examination of a topic was structured so that the presentation of basic information was followed by a work session, where participants were encouraged to work together or alone to develop a product that could be used in their own practice. When participants were not in class, they were at the hotel, often together. Evening activities became a powerful component of the informal curriculum, networking and developing a trust community with each other. From the first year through the fourth, fluid subgroups formed, identifiable by who went out to dinner together. In Years 1 and 2 evening sessions devoted to poetry were conducted using Fleischman's ***Joyful Noise: Poems for Two Voices***. The evening session in Year 3 extended the social justice theme by introducing the participants to hip hop pedagogy culminating with creation of a science-themed hip hop song. During Year 4 this activity was embedded in the "Teaching diverse populations" module. These activities proved a powerful component of the professional development.

Outcomes from the four years of the Science Education Faculty academy include many indicators of effective professional development and community building. The SEFA has a Facebook page where, from the first year, participants posted professional and personal notices. We learned of the birth of our first SEFA baby via Facebook. The participant learned she was pregnant just before she arrived for the SEFA and, yes, when she returned three years later she discovered she was carrying her second! We learned that a participant had used the PBL ideas from SEFA at her institution and consequently received a faculty award in her second year as higher education faculty. We responded to queries about curriculum "Does anyone know a good approach to teaching X?" Because of the SEFA, there is now a network of science education faculty in Virginia who know each other and who continue to work together on various projects.

Within-community leadership development has become an outcome of the SEFA. In 2011 a SEFA participant was recruited by a SEFA organizer to chair the College and University Committee for VAST. She was new to Virginia and found the chairmanship to be a quick entrée to the culture of science education. In 2014 we began to incorporate SEFA alumnae into the SEFA instructional staff. This same 2011 alumna served on the SEFA planning team, edited V&V's, and led several topic sessions at the SEFA. Also, SEFA alumnae consulted with SEFA leaders on grants, and a SEFA alumnus was hired by a SEFA leader to assist with an NCATE re-submission. Two SEFA alumna led one of the VISTA Elementary Science Institutes in the summer of 2014. Publications, presentations, grants, professional development partnerships, and consulting opportunities are all tangible outcomes of SEFA.

This grant will end. We have one more year of the SEFA, and little prospect for any extension of this grant. We are vexed at the potential that the energy that sustains this very strong community of science educators will fade as the focused and financially supported activities of the SEFA end. We fear that the result will be a diminished community of practice and practice community among K-12 science educators in Virginia, leading to a fragmentation of effort and lack of coherence across the state in approaches to training K-12 science educators and also that talented science educators will go undeveloped.

WE THINK ONE APPROACH COULD BE ESTABLISHING SOMETHING like a Virginia Science Educator Faculty Network. There is money available to us that would allow us to offer dinner out on the town (in a very nice restaurant – with drinks!) to any science educator who wants to attend. We've held these dinners already, on the first night of the VAST conference. They actually were a catalyst in establishing the SEFA. We could easily maintain the Facebook page, and we think we should. We wonder if we should be thinking about a new page, or should open up the page to all science education faculty in Virginia, not just SEFA participants. We want our SEFA alumni to have this network of friends to call on for whatever they need, want, or wonder about. When new faculty in science education enter one of our institutions, we want them to be invited to be part of a community across Virginia that works together for the good of all. Questions we have: Should we actively pursue funding to continue providing maybe a 3-day SEFA with the V&V for new science education faculty? How might we support and maintain this network in other ways? What should we be looking to disseminate from our project and how should we do so?

The contents of this paper were developed under a grant from the U.S. Department of Education, Investing in Innovation (i3) Program. However, those contents do not necessarily represent the policy of the U.S. Department of Education, and you should not assume endorsement by the Federal government.

my notes

Welcome to the Reality Science Museum

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FOR YEARS I'VE THOUGHT, "WE'RE DOING THIS WRONG." As an informal science educator for over 20 years, working primarily through science museums, I've felt a complicated tension between institutional educational goals and the interests and insights of visitors. Where was the space for teachers' expertise, or the negative scientific (often medical) experiences of families? More recently, working in STEM retention and support programs at a large public university, I've seen these complicated and contradictory goals undercut promising programs and shortchange promising students. How can students feel free to explore the broad fields of science if they can't afford an extra year of school to strengthen their content or academic management skills? How can student support programs build from rocky starts if they must report gains each year? How can students trust their advisor's intentions if those students know their persistence in science is key to that advisor's job and funding? My vexation is that the two primary goals for science education — a) raising the science content knowledge of all citizens to an unspecified level of "literacy" and, b) bolstering the scientific workforce — are outdated and no longer aligned with the needs and experiences of science learners.

The two primary goals of American science education can be traced to the Great Depression and the Cold War, periods in American history when public knowledge about science and technology were viewed as integral to America's future. In the late 1920s and 1930s, industrialization was altering urban spaces and the nature of work. In addition, scientific research was continuing to reconfigure the industrial process. Industrialists, engineers and scientists believed that public faith in science and industry, suffering from the economic distress, depended on public knowledge about how to work in increasingly scientific factories and use the new products those factories produced. In this view, Americans well versed in science and industry were Americans capable of participating in America's return to economic health (see MacMahon, 1935). Museums of science and industry were created in the 1930s with the expectation that industrial museums could achieve these goals. Following WWII, the Cold War increased urgency to strengthen the public's knowledge about science, and the scientific workforce. Schools became key spaces for enlisting and training scientific workers and supporters (see Rudolph, 2002). Not only did beating the Russians require scientific and engineering workers, but a fully modern populace enjoying the bounty of American industry was seen as critical to maintaining domestic optimism and global preeminence. In sum, these goals for science education were responses to important economic and political conditions of their time.

The early twenty-first century is a very different historical moment with different challenges requiring different approaches. Without the defining nemesis the Cold War provided, what is the real value of American exceptionalism when issues like climate change require action on a global scale? Moreover, can American expectations for outcompeting the world facilitate meaningful multinational collaborations? In addition, research in the fields of science and technology studies (STS, including history, sociology, anthropology, and philosophy of science, technology, and medicine) are providing powerful new tools for understanding the counterintuitive ways science and technology function in society. What is the cost of overlooking this research and continuing to follow the scientific establishment's leadership in shaping science education? In so doing, we often ignore the wisdom of experiences of the public. What do we lose when we ignore the lived scientific experiences of American and global citizens, pushing aside topics like environmental racism and the technology divide, to assert the overall beneficence and success of American science and technology? How do these oversights contribute to the lack of diversity in the science workforce? How does this selective science discourse build the distrust that the Great Depression-era science education goals attempted to ameliorate? These questions underscore the inappropriateness of our current approaches. Science educators, working under a set of outdated ideologies are not positioned to meet the challenges that we have historically been asked to meet.

THROUGHOUT THEIR HISTORY, AMERICAN SCIENCE MUSEUMS HAVE BEEN LEADERS in science education. I envision a new type of science museum that would serve as a model for moving past outdated ideologies. Building on Bradburne's critique of science museums (1998), I'd like to create a new type of science museum, one that moves beyond simply presenting by instead researching and demonstrating how science and technology operate in social spaces, based on the work of scholars and citizens alike. The result will be a fluid space that constantly refines our understanding of science, technology, and medicine in

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society, while also working with visitors to build tools and resources for science and technology concerns and action. This new type of science museum —which I'll clumsily call the Reality Science Museum (RSM); it needs a better name — will operate with the goal of accurately representing science, with all of its complications and contradictions. The work of the RSM will include research, exhibits, and programs, each of which I have sketched out below.

RSM Research - The Nature of Science in Society. The RSM will be an active research institution, applying a critical lens to studying how science, technology, and medicine function in society. The research program could focus on public understanding of science, looking at how ideas about science are produced, reproduced, and changed in media, formal and informal science education, advertising, and in everyday contexts, such as medicine, diet, landscaping, and home technologies. The research agenda could be more expansive, but a critical focus on science, technology, and medicine in public discourse would be a powerful new resource. "Understanding" would not simply be a synonym for "knowledge."

Sample research project: Qualitative analysis of scientific understanding and application among adults in various religious groups.

RSM Exhibits - Science in (Accurate) Context. The exhibits in the RSM would be relatively familiar, but with a contextual twist. Objects and experiences will be grounded with important, often overlooked, questions. As with the best science museums, I still want visitors to be amazed by natural and human-made wonders, but to also think critically about how they relate to those objects and what those objects tell us about the nature of science and technology. Experiences will not only develop scientific behaviors, but also expose unexpected aspects of scientific work. Much of this critical context will be drawn from research in STS, such as Cowan's argument that domestic technologies actually increased the work of women (1992), or Wynne's work on scientific expertise among non-scientists (1992). For citizens and prospective scientists and engineers, access and agency require more than knowledge; they require the capacity to ask questions and find novel answers. With this in mind, RSM visitors will develop critical approaches to understanding science, not work toward the limited concept of literacy.

Sample exhibit theme: Our culture of cures – Why American medicine values medication and intervention over prevention and management [Title wouldn't draw visitors, but hopefully provides a useful example]

RSM Programs - Beyond Teaching to Co-constructing Knowledge. The key to RSM programs will be the assumption that expertise exists in all phases of society. Classroom science teachers would be active and equal participants in developing new science curricula. Workshop participants won't just listen and ask questions, but will be asked questions and contribute to understanding the topics discussed. This aspect of the RSM requires the most consideration and development. A full suite of museum educational programs, including teacher professional development, outreach, school tours, and youth programs is expected, with additional evening and weekend programs for adults.

Sample program: An annual summer seminar delivered by science teachers, reflecting on what worked in their science classrooms, what didn't work, and what they learned while working with students and their families. The seminar would include workshops to modify instruction based on the teachers' observations.

Discussion Primer Questions–

1. **What personal and/or professional resources do you draw from when supplementing science curriculum to improve its effectiveness in your classroom or practice?**
2. **It is common for science educators in various spaces to show learners connections between science, technology, medicine, computer science, and even science education, effectively grouping them into one large category. In your personal experiences, what makes these categories different? Do explanations you hear about the nature of science hold true for your thinking about, for example, doctors, mobile technology, or even your diet?**

Lurching Toward Utopia: Starting Up a Teacher Learning Community

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MY VEXATION STEMS FROM MY INHERENT DISTRUST OF THE TOOLS or the mechanisms of change typically employed to support teacher learning and change in schools. The vast majority of reform and professional development programs rely heavily on curriculum as an agent of change in schools. Sometimes using curricula as an agent of change is primary, as you can see most directly in curricula funded by the NSF over the last two decades (e.g. FOSS, BSCS, PBIS, iQuest, etc.). In many cases the reliance on curriculum is more implicit. For example, in many professional development programs teachers are asked to use/transform/develop curricular products (typically lesson plans) and bring these new curricular artifacts back to their classroom to implement.

The message to teachers is ***tools/artifacts can carry the purpose(s) of the practices underlying the tools in unambiguous ways***. That is, teachers can use the lesson plans or other curricular artifacts "in high fidelity" with the original purposes or aligned with, for example, ambitious and equitable notions of teaching (Windschitl, Thompson, Braaten & Stroupe, 2012). For me, this does not take into account (nearly enough) the interpretive flexibility of curricula as artifacts, and in particular the potential for not only productive variation (well aligned reinterpretation supporting ambitious and equitable contextual use), but also lethal mutation (ill-aligned reinterpretation supporting status quo contextual use).

There is a tension that exists between providing teachers with tools that have been developed by someone else and supporting teachers in developing their own tools that have a local contextual meaning. The first reduces effort in the area of tool development on the part of the teachers, but it reduces some of their autonomy. The second makes their local professional community primary, but has the potential to result in a focus on less meaningful practices and more time spent on tools rather than improving teaching.

In the past, I have largely seen my role in teacher learning as engaging teachers in deep, empirically grounded, contextualized, dialogues about the purposes of practice(s), while using representations of practice sparingly as a way to carry meaning. I recognize this approach is both grounded in my theoretical approach to learning and at the same time blithely ignorant of the power of tools (including curricular ones) to support teacher learning. Thus, we have come to my vexation: ***How do you develop tools (and professional development contexts for tool use) that can support teacher learning and teacher practice, minimize lethal mutations and maximize productive variation***?

THE IMPORTANCE OF THIS VEXATION for me that for 10 years I have been lurching, two steps forward and one step back fashion, toward working with a group of teachers in my local district. I am on the eve of starting something this fall, and ***I will have only once chance to start it well***. With my preservice teachers I can delude myself that I can develop taken-as-shared meanings of practices at least until they move into their field placements; however, with inservice teachers, they have been and remain in schools everyday. They are part of the status quo conversations about teaching (by definition), without me having any ability to mediate or even contribute to that conversation, so having tools to be there to support their practices seems critically important.

For the past four years I have been working with inservice teachers as part of an NSF grant focused on middle grades Earth and Space Science teaching. The structure of the professional development involves week-long summer workshops and three meetings during the academic year that happen on weekends. The science content foci of the summer workshops includes Plate Tectonics, Solar System Astronomy, Climate, and Energy. The pedagogical focus of the workshops has been on developing classrooms norms around the Claims, Evidence and Reasoning (CER) Framework (Zembal-Saul, McNeill, and Hershberger, 2013) and designing curriculum around a coherent content storyline (Roth, 2006) while beginning to incorporate ambitious and equitable science teaching practices (Windschitl, Thompson, Braaten & Stroupe, 2012). Not all content area workshops are offered each summer, but teachers can attend multiple workshops in a summer and attend for multiple years, even returning to the same content focused workshop for multiple years. The intention of the project is to build a cohort of teacher leaders in Earth and Space Science that have collegial support both within their district and outside of it.

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The academic year meetings include a conference in the fall (Pennsylvania Earth and Space Science Teachers Association meeting), and two one-day meetings in January and May. As part of the academic year meetings I have begun using the V&V/Crossroads model as a way of developing professional and instructional leadership among the teachers. For example, at the Pennsylvania Earth and Space Science Teachers Association (PAESTA) meeting, I co-presented an (un)keynote about teacher leadership with Theresa Lewis-King, a teacher colleague from Philadelphia, which engaged teachers in a micro scale version of crossroads. We gave them an index card, first asked them to write a short vexation on one side of the card and then discuss it in small groups. Then we asked them to flip the card and describe a venture associated with the vexation, and then ran an abbreviated critical friends protocol at each table of 5-8 teachers. We had one teacher, identified before the talk, with experience with the protocol sitting at each table as a facilitator. We were able to "workshop" two teachers' ideas before our time was up.

All of this work with teachers seems to have been building toward my current vexational context. Last summer I had a group of four 7th and 8th grade teachers in the same middle school from my local school district in my Energy workshop. They got excited and this past year have been experimenting on their own in their classrooms with ideas from the workshop. During this year I have had little interaction with the teachers as they engage in this experimentation, but it has drawn the interest of the secondary science department head/curriculum coordinator in the district. He asked me to meet with teachers in both middle schools in the fall to talk about CER and storyline. This spring I have been working with two of the teachers, the department head and the building principal to begin a study group for these 7th and 8th grade teacher as part of their differentiated supervision plan for the 2014-15 academic year. This would mean at least monthly meetings with this group, and possibly expanding to the 6th grade teachers in this building and the science teachers in the other middle school. In addition, all the teachers in the school are in my summer workshop this summer, along with two 7th and 8th grade teachers from the other middle school. It seems like it is all coming together, but I am also aware that these relationships are delicate and require cultivation.

Thus, my venture is underway, a veritable freight train of professional learning potential. However, the train is approaching a tunnel, a place where I will have to make difficult choices with imperfect information; choices that will impact my professional life, the professional lives of a group of teachers, the lives of their students (including my children). Megalomania aside, I would like to make the best ones that I can and spend my limited social capital well, to effect the largest change that is possible. This might mean (and I increasingly think it does mean) using material representations of practice that can carry/hold purposes of practice (i.e. tools), but I am only beginning to know what they tools look like and how they can be effectively used to support professional teacher learning. Here are some wonderings I have that I would love feedback on from the excellent Crossroads community:

- Would a V&V format be a productive way to launch a beginning professional community? My worry is it would lead to too much diversity in focus to create a coherent community over time.
- What about using a driver diagram from Design Based Implementation Research?
- Are there other tools people have found success with when starting a community of teacher learning?

Promoting the Participation of English Language Learners in Science Practices: Questions for a Research Practice Partnership

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NEW APPROACHES TO SCIENCE EDUCATION (e.g., the Framework for K-12 Science Education and the Next Generation Science Standards) highlight participation in science practices as a vehicle for science learning. A key premise is that by engaging in the practices of science and engineering, students can gain a direct experience of how science knowledge develops. Further, by engaging in practices to understand the big ideas of science, students can gain an appreciation for how scientists investigate, model, and explain the natural world.

The use of specialized forms of language is implicated in a number of science practices. Indeed, it is difficult to imagine how students might construct explanations or engage in argumentation without sharing their ideas, or listening carefully and responding constructively to their peers'. In practice, however, students have little opportunity to engage in the kinds of conversations that facilitate participation in science practices. More commonly, students are expected to provide brief responses to questions posed by the teacher, which test their recall of science facts instead of providing opportunities to reason about ideas.

This problem is amplified for English Language Learners (ELLs). Few ELLs come to school socialized into using the explicit forms of language favored in school. In their efforts to engage ELLs, many teachers' first recourse is to simplify the language and the content of science learning experiences, which has the consequence of watering down the curriculum and denying ELLs the opportunity to access academically rigorous material. As such, it is rare for ELLs to be presented with opportunities (and the scaffolds) for reasoned discussion—where they can formulate ideas, justify their thinking with reasoning, and engage with the thinking and reasoning of others—and by extension, in science practices.

At the same time, the present turn in science education presents an opportunity for examining, contesting, and interrupting these status quo practices. In the context of the orientation towards science practices, science classrooms can, arguably, be considered language in use environments. Planning and conducting investigations, developing and using models, and interpreting data have the potential to engage students in purposeful science activities, which in turn provide rich context for language use and for supporting students to *do* things with language (Quinn, Lee, & Valdes, 2012). Students can ask questions, make predictions, and explain results and causes, thereby learning science at the same time that they are acquiring familiarity with the language of science.

If the bold vision of the Framework and the NGSS is to benefit all students including ELLs, many of whom come from low-income communities, it is imperative that members of the science education community: (1) understand the motivations underlying prevalent patterns of instruction that constrain ELLs' participation in science practices, and (2) identify disruptive tools and strategies to help teachers enact ambitious pedagogy that will support ELLs construct knowledge through new and unfamiliar ways of using language.

With these goals in mind, my colleagues and I have been engaged in a small-scale exploration with a group of 7th grade teachers in a diverse urban school district characterized by a high concentration of ELLs. Located in a state that has adopted the NGSS, the district is on a trajectory for full implementation in the 2015-16 school year. Over the last year, we have

1) Interviewed teachers to learn about their backgrounds and contexts, and the conditions under which they orchestrate science learning experiences,
2) Interviewed a sample of students in each teacher's classroom to learn about students' in-school science learning experiences, exposure to science outside of school, and perceptions of science,
3) Visited classrooms to observe and video record instruction.

Our experiences working with these teachers and the analysis of our data highlight a number of issues with which science educators must wrestle if we are committed to translating the promise of the Framework and the NGSS into a reality for all students.

- Orchestrating instruction where students learn science by doing and talking about science is a challenge, given the reality of under-resourced schools. Although an investigation-oriented curriculum is in place in the district, its use is uneven across schools. Some schools lack enough books for all

students, and in all schools, it is an ongoing challenge to find the resources to replenish consumables necessary for hands-on investigations.

- Learning science involves demonstrating mastery of facts rather than appropriating the tools and practices for making sense of scientific phenomena. During classroom discussions, teachers do most of the talking—and the intellectual heavy lifting: they pose questions targeting discrete science facts, and respond to students by restating, evaluating, and elaborating on students' contributions. Students' opportunities to participate in the discussion are constrained, confined to brief utterances with high expectations for producing the right answer. They are rarely expected to elaborate on their ideas or to agree, disagree, or build upon the ideas of their peers.
- The teachers are candid about their struggles to differentiate instruction for particular groups of students. They talk about struggling to "push the lower kids without making them feel that they did not get something" and repeating explanations of concepts but "in a different way so the faster kids don't lose interest." Structuring group work in a way that takes advantage of the heterogeneous nature of the classrooms—while seductive in principle—is challenging in practice, and the teachers talk about the difficulty of making small groups work when the "kids are too far apart."
- Teachers' views of students—and their reservations about students' capacity for handling the academic and linguistic challenges of science learning—also influence their instructional practices. They underscore students' lack of background knowledge, noting that "the inquiry-based [approach] is so far above my kids' heads" that "my particular kids miss the bigger picture" while learning about science topics. They point out that many students speak English "fairly well" but "not well enough", and that reading and comprehending academic texts is an area of difficulty for most students.

The vexations I describe above, situated in a particular school district and its schools and classrooms, are by no means unique—they resonate with my experiences in other settings and the experiences of other educators. The field of science education has grappled with the question of how best to organize science learning so as to demand, reinforce, and produce academic excellence for underrepresented groups such as ELLs for a number of years. However, I am optimistic that the current policy landscape, coupled with emerging approaches to research-practice collaborations, might offer new perspectives.

MY COLLEAGUES AND I ARE BEGINNING TO EXPLORE WHAT IT MEANS TO GROUND OUR WORK—and our partnerships with practitioners—in Design-Based Implementation Research (DBIR; Penuel, Fishman, Sabelli & Cheng, 2011), an approach that is characterized by: (a) a focus on persistent problems of practice from multiple stakeholders' perspectives; (b) a commitment to iterative, collaborative design; (c) a concern with developing theory related to both classroom learning and implementation through systematic inquiry; and (d) a concern with developing capacity for sustaining change in systems.

As we near the conclusion of our analyses, my colleagues and I have the opportunity to share our findings with district stakeholders, and discuss next steps. Given my predisposition to locate this work in a DBIR approach, identifying the persistent problems of practice and addressing them through iterative, collaborative design emerge as key considerations. In this context, a number of other questions surface, including: How do we describe our observations without being overly deterministic, that is, in a way that allows district stakeholders to insert their views and challenge ours? How do we navigate the ethics of writing and communicating about problematic classrooms in the context of a research-practice partnership in a manner that honors our practitioner colleagues? How do we recognize constraints and challenges without being paralyzed by them?

My venture involves exploring what it means to facilitate 'intense educational conversations' among district stakeholders about improving the quality of ELLs' science learning opportunities. Creating the space for multiple voices, views, expertise, questions, and challenges is a priority for this conversation, as are strategies for blurring traditional power differences—such as those between researchers and practitioners or teachers and administrators—and building trust among stakeholders. In this context, 'Ventures and Vexations' appears to be an intriguing format for structuring discussions and I am interested in thinking deeply, in the company of thoughtful colleagues who will challenge my ideas, about what it would mean to apply it in the context of a research-practice partnership.

Forming Project Alliances BECAUSE of Our Difference

Terri Patchen
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THE VEXATION I RAISED AT THE 2011 CROSSROADS CONFERENCE (i.e. I am "not a science person" or NASP) resulted in more dissonance than I anticipated. Even though I unequivocally asserted that I was a lover of science education research, raising the issue of my NASP-iness prompted a heated discussion. Participants rapidly assured me that I was a science person: I understand the science process, and "it's not rocket science," after all.

Yet their assurances seemed to highlight rather than erase the dichotomy, even in the safe space of Crossroads. It was obvious I'd hit a nerve: I was either a science person (ASP), an identity most in the room appeared to share, or I was "defensive," a "denying," and "stereotyping" usurper (ouch!). Neither position seemed to fit well (indeed, this was my initial vexation) and that's when I realized that the notion of identity for science educators is far more fraught than I recognized. My wee lark of a vexation was soon overwhelmed by an albatross of simmering vulnerabilities. What had been a private conundrum appeared to be a highly charged issue, of particular importance to those working in science education, and one therefore that merits attention.

Undoubtedly, the issue of identity is complex, and no less so in science or among science educators than elsewhere, and I should have treaded more carefully. I know, for example, that the notion of a science identity comprises more exclusions than inclusions: women and ethnic minorities remain ill represented in science classrooms and professions (Brown, Reveles, & Kelly, 2005; Carlone & Johnson, 2007; Malone & Barabino, 2009), positivism reigns supreme, and cultural relevance in science is more often superficial than substantive (Patchen & Cox-Petersen, 2008). Yet, even though there is increasing theoretical recognition that builds upon feminist theories arguing that identity is not a zero-sum game (see, e.g., Endedy, Goldberg, & Welsh, 2005), in practice identity often plays (or better still, gets "played") differently. Singular positions continue to dominate, and fluidity, for all its resonance, can be hard to achieve. Essentialist positions inform how we are perceived, even if they do not hold sway over the entirety of our self-perceptions.

Regardless of theoretical shifts, therefore, I cannot sit idly by and let this "identifying" moment define those of us who are interested in working in science education but do not identify as "science people." I cannot accept that one must identify as a science person in order to interact with, contribute to, or learn from those who do identify as science people. Feminists and queer theorists have worked too hard for this type of "you're in" or "you're out" Heidi Klum dichotomy to persist unquestioned; they have long recognized the obfuscation such essentializing prompts (Butler, 1999; Pfeffer, 2012). Instead, we need to consider how we can open more doors for the NASPs among us, without insisting they get a science identity card before they can come in.

My vexation, therefore, is with the dichotomizing of NASPs and ASPs; a division that too often neglects to problematize the relationship between the two. Although I recognize there are important distinctions – rocket science *is* science (involving aerodynamics, propulsion, avionics, and structural analysis), and a wet chemistry lab is not some low-rent pornographic film – I think we are better served by seeing these as positions on a continuum. I do believe there are real differences between scientists and me (and each other), but I do not think these differences mean we have nothing to offer one another or, moreover, that distinguishing identities precludes interdisciplinary or inter-identity work. On the contrary, the cross-pollination of these disparate types of identities results in great science and great social science.

STUDENTS ARE ALWAYS BEING TOLD THAT WORKING WITH OTHERS better prepares them for the diversity of the workplace. Yet as adults many of us go to great lengths to secure the fortresses of what we know – nurturing, aiming for, and protecting what we are already familiar with, even as we push students to do things differently. We do this while recognizing that the most meaningful collaborations are those that come from the unexpected: a poetry reading at a science educator conference; blue bread mold that leads to penicillin; Frank Epperson's Popsicles™; or Greatbatch's pacemaker!

My venture, therefore, is to move past the labels (without abandoning or denigrating them) by dragging our disparate identities into the unknown, subverting boundaries as we do so (Star & Bowker, 2007). In this way we can both recognize and build upon difference in ways that are not limited by oppositional binaries. Instead, in clambering over these boundaries, we might work together to develop and cultivate ideas, partnerships, and perhaps, if we are lucky, popsicles of our own.

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In order to diversify the ways in which we think about the NASP←→ASP continuum, I would like Crossroad participants to consider the implementation of some type of mechanism for cross-disciplinary project development. To this end, I suggest we "cross" a few things ourselves, looking to the work of transgender artists (see, e.g., the work of Zackary Drucker, http://zackarydrucker.com/ or Wu Tsang, http://wutsang.com/ for inspiration. Like Cindy Sherman, Drucker and Wu are artists who cross gender boundaries by unbuckling and unsnapping traditional and hierarchical notions of identity ("It's a boy!" "No, no! It's a girl!!"); their work may teach us a thing or two about shifting positions between representational, relational, and "real" terrains. Following the lead of artists who subvert traditional conceptions of gender identity and representation might be a way to really put the "cross" in Crossroads.

Similarly (or, if you wish, *differently*), cross-disciplinary projects initiated at Crossroads could take many forms, but we might try and instigate them through interactions and introductions cultivated through the incubators. I understand this idea was introduced before, albeit it in a different (better?) form (Johnson, 2007), but as a NASP determined to find a reason to keep getting Crossroads invitations, I can't let this opportunity slip by. I'd like to know how others think we might more actively foster collaborative action at the conference. Could we, for example, add a component to the incubators — a sort of "dance card" — in which we list ideas for collaborating with those who are sharing their V&Vs? Besides providing opportunities to discuss individuals' ideas, incubator sessions could be used to cultivate collaborations (NASP←→ASP, and otherwise). We could consider theoretical and practical intersections, or extensions with one another, building connections between ideas and generating possibilities for collaboration. Newly formed alliances could then be developed over the following year, and participants could consider "doubling down" at the next Crossroads: bringing in preliminary results from their collaborations to enlist others in their cross-disciplinary efforts.

My venture prompts a few questions:

1) What would it take for participants to start collaborating with those who use different theoretical frameworks, populations, or methodologies?
2) What sort of cross-collaborative practices might we cultivate together at *Crossroads*?
3) What risks might we face? In other words, what are the costs of crossing these boundaries many of us have worked so hard to build?

Journey of Recruitment by the Sea

Megan Pichette
University of Connecticut – Avery Point

I AM NOT SURE THAT I EVER WOULD HAVE GUESSED that I would be a program assistant for a teacher education program, especially after being a social worker for 12 years. Some days I really feel that I've come full circle. By that I mean coming back to the UConn community; it was here that I began my higher education career. When I was a sophomore at UConn, I was not the strongest student and therefore could not follow my childhood dream of being a teacher. Consequently, I went with my passion for feelings and emotions and became a social worker. I believed I had chosen the career path I would serve in for the rest of my life – until neither my family nor I could handle it any longer. As I write this I realize that my purpose is two-fold, the first part being personal and the second being my strong belief in the program that I now work for.

My experiences in many different areas (urban, suburban, rural, as well as non-profit vs. state), gave me a "leg up" in the social work world – I was considered an expert. I was sought out for opinions and advice about how to handle situations; I spent countless hours working one on one with children and families to ensure the safety and wellbeing of the people in those homes. But, the trauma got to be too much and I had changed as a person. I became short tempered and no longer enjoyed life as I knew it. This change was invisible to me until someone very dear pointed it out. I began to realize the daily exposure to these types of trauma was having negative impact on all aspects of my life. I knew at that moment I needed to make a change. However, I was also fearful of never utilizing those "expert" skills ever again. Thankfully, along came a STEM teacher preparation program at Avery Point.

When I joined the Teacher Certification Program for College Graduates, (TCPCG for short) program in December 2012, I was ready for the change and ready for a challenge to begin, although not truly sure what this challenge would entail. Since then I have more than utilized my social work skills – both in the classroom and out of the classroom. Every day I am interacting with students, new recruits, Neag faculty and staff, other campus staff and personnel and school districts. The most rewarding of all of these interactions for me are those with the students, whether helping them to better understand the State of CT Child Protection system or drying tears from stress and feeling overwhelmed. This is a place where I truly see the fruits of my labor and my passion for helping people.

My husband graduated from the same teacher preparation program at a different campus. Although he was a history major, I was familiar with the theories, the coursework and the benefits of this program. I knew about the care and connection the faculty and staff had with the students, to the placements sought in local school districts, and finally the assistance with taking the next step after graduation and ensuring that students were well-prepared. I was aware of the benefits of TCPCG and I believe in the mission of TCPCG, but I was not aware of the amazing things that TCPCG Avery Point was going to do. From the very beginning, prior to any student being offered admission, we (John Settlage and I) were thinking about how to make this teacher education program different, more practical. Diversity and multiculturalism are a major focus, for both students and curriculum. It was already a unique program due to the focus on STEM (which in Connecticut really means science and math) but why else?

John and I spend countless hours working on the perfect mixture of practicality, education, real life experience and allowing the students to fall down and pick themselves up. This "science" has proven to be time consuming, yet part of what makes our Avery Point program stand out. It is a close knit, attention to detail program. The focus on recruiting non-traditional teachers with a science or math background is at the forefront of our minds.

When TCPCG Avery Point began, there were 20 applicants to the program who had been recruited through faculty interactions, open houses and newspaper advertisements. We interviewed each and every one of those applicants, searching for teacher diamonds-in-the-rough in each of them. At the end of the day, we offered all but one student admission into the TCPCG Program. That would be 19 students for our first year with 24 slots available, but we were ecstatic! As time went on, we lost a few to the financial and time constraints so that there were 12 that began the program on May 31, 2013.

All of the TCPCG students had science and/or math background. The degrees ranged from engineering to geoscience and students had experiences ranging from archaeology digs to digitally mapping the social networks of ducks. They were a quirky bunch that melded well together while still maintaining their

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individuality. The first several months of the program went fantastically until I started to think about recruitment for next year. The panic then set in – how am I to find smart, energetic, science and math people with the correct amount of credits, who live nearby or at least are willing to travel to our campus, who don't need to work in order to survive, and want to become science and math teachers to middle and high school students?

I KNOW THAT I AM NOT THE ONLY PERSON DRIVING THE BUS, nor am I the only person wanting to stay on the bus as it travels down the road. The obstacles that I have encountered along the way involve forms and check boxes for which we must figure out how to "fit things" in order to change people's lives. There are also my own struggles with feeling as if I do not belong among the smart science and math enthusiasts, and finding people who are a good fit for TCPCG.

The near future at UConn, specifically the next 2 years at the Neag School, will be very important for TCPCG Avery Point. There is a current faculty member returning as Dean who is passionate about Teacher Preparation and the TCPCG program he developed over 10 years ago during his initial deanship. My hope is that his presence will have a significant impact on positive changes for TCPCG Avery Point and the program will soar to new heights. My wish is that we grow bigger, faster, yet all the while smarter. I want to continue the tradition of a small close-knit community in our classrooms by hand-picking our student teaching placements and being able to do this because we know each and every student. I want to continue to find those special science and math individuals who are seeking to change the lives of young people in America or beyond through becoming teachers.

- ***How might I work around some of the technical requirements to accommodate non-traditional teacher applicants?***

TCPCG was developed to allow people who did not choose a traditional teacher preparation route to follow their dream of changing the lives of children through the hard work of teaching and learning. This program is specifically designed for career changers and nontraditional students; those are the students who might not have all the courses in the correct order on their transcripts. However, it's frustrating to have to discount all their accomplishments by turning them away just because they don't have the exact course to fit into the check box. John and I have been successful at finding something to "fit" into the forms and checkboxes in order to help change people's lives. However, when we are able to do this and then lobby to those with the power to make exceptions, we are often shut down because people are unwilling to stand up and support decisions they make for fear they might have to defend those decisions at a later date to someone in a more authoritative position. How do I prevent, defend or combat this issue?

- ***How do I go about recruiting high quality applicants with math and science backgrounds when I don't feel as though I belong in a science/math world?***

To go from being recognized as an "expert" in your field to a world of science and math in which you admittedly know very little, can be difficult to navigate. I struggle with feeling as if I do not belong in a world of science and math enthusiasts we are looking to recruit. My fear is that this personal struggle will begin to have a negative impact on my efforts to recruit math and science students for the program. My hope is that my skill of being able to interact with people and always being willing to listen and help will help to negate this issue, but how does an "outsider" go about successful recruitment in a program such as TCPCG?

- ***What are the best recruitment strategies for TCPCG Avery Point?***

What we've done thus far has been standard recruitment protocol. We have held open houses, advertised in the local newspaper, online and on campus. We've attempted to advertise on NPR's Science Fridays to lure individuals to our open houses. We have also tried to get to a younger generation by advertising on Pandora radio. Finally, some of our current students were recruited personally and successfully by John. Recognizing the marketing budget isn't limitless and simply guessing about what might work can be frustrating. Additionally, the range of where students have come from/heard about the program is rather wide which makes it daunting to determine which strategies are most effective! So the question for me is where to go to find those teacher diamonds with science and math backgrounds willing to come be a part of an amazing teacher education program?

Rejecting Mediocrity and Accepting Excellence: The Role of an Action-Researching Teacher/Teacher-Leader/Pre-service Teacher Educator

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Manchester (CT) High School

I HAVE RESORTED TO GUERILLA TACTICS. I just finished spending the past few hours baking several batches of cupcakes for two of my classes. One class won the challenge I put forth for 100% homework completion and the other won the school-wide "ICOT" (In Class On Time) challenge last week. (And if the school board asks, by "cupcakes" I mean carrot sticks and 100% fruit juice.) External rewards work, but I honestly don't get to reward my students in this manner very often. Now don't get me wrong, I propose rewards and many different kinds of rewards all the time. Free time, activity choice, no homework, a chance to make up an assignment – you name it, I've tried it. The problem is, I expect 100% buy-in in order to receive the reward, and I rarely get 100% achievement of the task.

My vexation isn't about rewards, though, rather about excellence and expectations. I expect excellence. I expect excellence of myself. I expect excellence from my colleagues. I expect excellence from my students. But the products I receive rarely demonstrate what I would consider excellent work. In the past year I have developed a model of standards-based learning incorporating curriculum compacting, differentiation, mixed flexible whole group and independent learning, blended learning, etc. in efforts to allow more student choice and to reiterate that it is not acceptable to choose to abstain from learning. What I witness in my school is a complacent "giving in" by much of the educational staff as their ideals and expectations of excellence become slowly eroded and replaced with acceptance of mediocrity. In addition, students choose or have learned to choose mediocrity. Only a few strive for excellence. I don't know what else I can possibly do to motivate, reward, and care for my students and their success. I struggle constantly with wanting a higher quality of product from my students and consistently not receiving it. It doesn't work if I want it more than them.

I'm not willing to accept this as our (mine and my students') fate. So when I take a step outside my classroom and look at the bigger picture, I find that perhaps this isn't an issue reliant on what I do as much as an issue of school or community climate and culture. Suddenly, I am expecting students to perform at a level that has previously not been expected of them in their 15 years of life, so of course they default to regular behavior. In the schools I have worked in, there is a pervasive attitude that students just "can't/don't/won't." These schools are demographically and ethnically diverse. The students that are expected to succeed are the honors students, the others just "can't/don't/won't." I have seen these students achieve. In my classroom, I witness a phenomenon: students are engaged and enjoy the class and the biology content. However, they are not motivated to complete unfinished work, consistently neglect homework, and effectively shut-down after leaving the class. In conversation with administrators in my school, it is clear the administration has also identified this phenomenon, however, they are also unclear about the variables and the supports that need to be in place for the students and for the staff. In effect, the administration is placing the same expectation of excellence on staff without providing proper supports to make the transition.

I have been identified as a teacher who believes all students can achieve and who implements strategies that can make this happen, and so I have been asked to work with a team of teachers whose collective students are identified as "at risk" (parameters for which were not disclosed to us). I have been asked to participate in a strategizing and brainstorming group that perhaps will begin to share out to our colleagues. I also am stepping into various teacher-leader roles and will be acting as PLC (professional learning community) Leader with my fellow biology colleagues. As a teacher-leader, how do I begin to broach this topic with my colleagues and administration? The conversations that the administrators are having seem not to "trickle down" and so there seems to be discord between what they are discussing and what is occurring in the classrooms, so how do I form the bridge? How do we get teachers to begin to have conversations about why students "won't" or "can't" that focuses on excellence and how to foster it, not on complaining about what we can't control? What we are doing to create that behavior? What is the best professional development that can provide teachers with the strategies to keep students from experiencing overload? Historically PD has been viewed as a waste of time, so how do we find PD that is meaningful and meets these objectives without seeming like another initiative?

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AS A TEACHER AND TEACHER-LEADER HOW DO I THINK ABOUT THIS PHENOMENON and how does my thinking then inform my practice? This discovery of framing my thoughts and collecting information and research about what I am experiencing is my current venture. I need to embark on my own personal "exploration phase." Questions arise: Are students and educators in other regions similarly not achieving excellence because of phenomena like what I have detailed above? Is this a phenomenon particular only to districts of great demographic and ethnic diversity? Does this come from or point to larger cultural implications? What makes some schools "successful" and what are the supports they put in place? What tools are used to measure "success?" How is excellence defined and why? I feel driven to gather this data through my own personal experience, in a sense conducting action-research. The impact this phenomenon has on my ability to teach and my students' ability to learn compels me to explore it further through the lens of teacher. How do I support students and teach them to choose excellence, always?

At the 2014 AERA Annual Meeting in Philadelphia I attended a presentation that sparked a few ideas in terms of identifying the root of this phenomenon. At this presentation, Marlon James, from Loyola University, spoke of his work at Excel Academy for Boys, a single gender middle school in Chicago. James proposed that he witnessed a "dissonance in expectations," where teachers and administrators expected academic excellence but expected poor behavioral outcomes, like the "won't" and "can't" mentality that I have observed. He quoted James Baldwin who wrote, "You were not expected to aspire to excellence: you were expected to make peace with mediocrity." James proposed expectation dissonance as the reason for what he called "expectations overload." His view was that the students were asked to move from an environment where mediocrity was expected to one where excellence was expected – but without sufficient supports for them achieve this transition. So the students just quit, and the teachers begin or continue thinking they can't/won't/don't.

So I have begun to think about this phenomenon in light of this dissonance. I am struggling and would like input on how to reconcile what I view as "excellence," the views of mainstream educational culture, and what theories state about the epitomized qualities of "success" and "excellence" of majority social group. I want the best for my students, but what IS the best for them? In several instances what has been proposed as means to increase achievement and excellence (read grades) is to limit amounts of homework and review work-loads. I understand these tactics as "quick-fixes" that may improve district numbers in terms of graduation rates, but will not approach the excellence dissonance phenomenon. I am also thinking about how this creates a dissonance that resonates in me internally. Do my views of academic excellence and learning contradict those of the district, of my colleagues, of what is socially equitable, and/or most importantly of my students? How is this impacting my teaching? What additional modes of thinking do I need to research in order to begin to understand this phenomenon in a way that can positively impact my students, and that as a teacher-leader I can model for my colleagues?

Once I have defined excellence in this manner and begun to understand how to think about expectation dissonance, perhaps I can then begin to pursue an action-research approach to defining a question and method for data collection. But I have a lot of thinking and observing to do first. And perhaps I need to redefine a few things for myself. Phew! I had to eat a cupcake and reward myself. Striving for personal excellence requires rewards too, otherwise what do we have to work for?

When Pedagogy Alone Doesn't Cut It: Increasing Regard for Science Education Contexts

John Settlage, *University of Connecticut*

SEVERAL YEARS AGO I WAS STARTLED TO DISCOVER that schools with similar student populations were generating such different science test results. No measure of teacher quality was sufficient to explain the differences within urban districts which led me to contemplate whether I could somehow study the school as a whole. Rather than concentrate on what takes place in the students' science classroom, I speculated that schools with smaller achievement disparities were helping their students accrue benefits over multiple years. Those results first appear when every Connecticut fifth grader takes the statewide science test. This represent a substantial shift as I discarded my research focus on classroom level phenomena.

Why would I step back from instructional practices and curriculum materials? In large part because arrogance about my individual capacity has been undermined as I have come to grips with the shortcomings of superhero mentality. Politically, I recognize the problems associated with the American exceptionalism paradigm (Bell, 1991); personally, there has been a shift because I now realize that my workplace exerts profound influences on me. I have only been able to survive, both as an educator but also as a human being, inasmuch as I have others to rely upon – to challenge, to encourage me, and to celebrate with me. The very existence of Crossroads is evidence of this dynamic because collaborators and co-conspirators rescued me from the ambivalence of my workplace. The corollary is the crushing feeling I experience when former students report their struggles to sustain themselves as teacher among their peers and supervisors.

A little context: Connecticut's 170 school districts are paragons of local control with almost all decisions made at the town level. For example, the residents must approve the town budget each year which means citizens use their votes to voice their views about local school operations. In my town, we have gone through four or more rounds of balloting over multiple months. Because there is no county system of government, each town operates unto itself. In true Yankee fashion, the self-reliant spirit translates into almost no collaboration across districts. A collateral outcome is that educational funding and student achievement is highly varied. This reduces incentives to coordinate efforts across town lines. Further, the State Department of Education's inactivity suggests either that they must accede to individual towns' decision-making OR that they have conceded that efforts to guide from the outside will be met with great resistance. This might not be a problem were it not for the fact that on NAEP, Connecticut had among the worst disparities in the nation when comparing White students' test performance to Black and Hispanic peers.

Despite the bleak situation, there are numerous metropolitan schools that defy the tendency to suffer lower science achievement as a consequence of enrolling children from low-income families, who are designated as English language learners, and/or are characterized as students of color. Because science tests are first administered in Grade 5 it is reasonable to treat the fifth-grade science results as measures of the cumulative effects on children's science learning over multiple years. This in turn suggests that the influences on science learning are not teacher-specific but byproducts of schoolwide influences (setting aside out-of-school factors). Truth be told, there is a considerable body of research demonstrating that leadership has indirect yet significant influences on student achievement – although this work has been almost exclusively with reading and mathematics. I am appropriating the theories and methodologies to investigate parallels for science achievement – with generous support from the National Science Foundation (EHR Grant #1119349).

By looking at education ecologically we eliminate the storyline of "the rescue" by a heroine or hero. We set aside questions about individual teacher qualities in favor of organizational infrastructures. We pay attention to the principal's ability to manage the building, provide science supports to the faculty, advocate for educational equity, and more. Instead, we rely on social capital theory to assist us in examining schoolwide interaction patterns, adult group norms, and the distribution of resources. We have uncovered significant school-level factors associated with reduced science test score disparities. The findings are consistent with other research showing significant connections between school organization and leadership – and students' test performance. Our work is unique because we focus on equity and science.

I was not prepared for the responses to this work by other science educators. Even those we consider allies have shown an indifference to the premise of this research. To paraphrase: "If you aren't going in classrooms – watching teachers and talking to students – then you are leaving out too much." Again: professional friends are reacting in this way and I am seeking powerful ways to shift their attitudes.

When Pedagogy Alone Doesn't Cut It: Increasing Regard for Science Education Contexts

John Settlage, *University of Connecticut*

CONTINUING TO FIXATE ON PEDAGOGY WILL NOT CLOSE SCIENCE ACHIEVEMENT GAPS. We need to step away from the drive to continue investing in curriculum development and implementation. Why the cynicism? Alone or together, pedagogical and curricular reforms have yet to show lasting influences on student achievement. Even though my research is personally invigorating, I often feel a like a pariah among science educators. I propose that we decenter teaching practices as our primary response to the challenges of inequitable science achievement. You don't have to agree with this stance. But entertain the possibilities for a moment. My venture is to become more persuasive, by better articulating this research.

My ambition is to use framing theory whereby I nominate a collection of resources (e.g., motivations, epistemologies, emotions, conventions, etc.) that helps others notice the value in viewing situations from a particular perspective (Hammer, Elby, Scherr & Redish, 2005). In particular, my goal is to frame the causes (and perhaps resolutions?) of science test performance disparities as a consequence of school contexts and not simply what takes place in classroom. I plan to begin with ***diagnostic framing*** that:

> problematizes and focuses attention on an issue, helps shape how the issue is perceived, and identifies who or what is culpable, thereby identifying the targets or sources of the outcomes sought. (Cress & Snow, 2000, p. 1071)

What I aspire to do is to frame the achievement gaps discussions in a fresh way. As a consequence, I would love to extract the science education community from super-hero paradigms in favor of school-level perspectives. In an effort to advance the utility of an ecological framing of schools, I have a few ideas:

- **Social Capital > Human Capital**. The rhetoric of turnaround reform is that school improvement requires having people with the right training in place. A successful school is captained by a brilliant administrator and science achievement is evidence of a talented teacher. This makes for good stories and "documentaries" but inherently blames schools that struggle as failures by individuals. The associated solution is to change out the parts – discarding the old teachers and inserting boot-camped souls from among the "best and brightest" universities. Each of us can attest to the influences of work environment on our effectiveness, for good or ill. Rather than focus on improving the individual components, how about regarding schools as ecological systems where actors and resources are intentionally aligned, in good supply, and well distributed?
- **Don't Fear the Unfamiliar.** Science educators are familiar with instructional moves like Wait Time and aware that students must negotiate between pre-existing knowledge and what is presented in class. We also know how to improve on the enactment of these approaches. In contrast, we have little understanding about deprivatizing teaching practices or how a principal might provide instructional leadership. Perhaps the resistance I sense is an epistemological issue? If so, then a lack of knowledge about thinking organizationally is one impediment and not knowing the practices of "doing" organizations is yet another obstruction (Cook & Brown, 1999). I suspect that the being unsure about how to intervene with organizational structures and science leadership practices contributes to the resistance to my research. Should I approach this as an educator by building understandings and appreciate – making the unknown more familiar?
- **Look to the Evidence.** So yes, we have data that shows how certain school organizational features are associated with more equitable performance on the statewide fifth grade science test. Our School Organization and Leadership in Science (**SOLIS**) teacher survey includes a factor called "Collaborative Teacher Learning in Science" and it is strongly correlated with more equitable science test scores. Teacher at better performing schools give a higher rating to items such as "Feedback from a colleague at this school has improved my science teaching" and "Professional development has strengthened collaborations around science instruction." Is empirical evidence and quantitative data going to swing opinions such that science educators will reconsider viewing organizational features as central to enduring school reforms?

Please understand, I'm not hurt or feeling rejected and I hope I am not coming across as crabby. It's simply that I am puzzled. Perhaps you are somebody who has hard time buying the desire to use the school as our level of analysis. If you can identify the source of your discomfort and suggest how I might work around those feelings, then perhaps we can meet in the middle so we can learn from each other.

WITH

Lara Smetana
Loyola University – Chicago

ENSURING THAT ALL STUDENTS HAVE ACCESS TO A HIGH-QUALITY, PUBLIC EDUCATION is among the most critical challenges facing the United States today. Teachers with extensive training and resiliency, particularly in densely populated, high-poverty and high-minority urban districts, are in demand. At the same time, debates about approaches to teacher preparation, teacher performance, development, evaluation and the meaning of "highly-qualified teachers" are fierce. Despite intensifying critiques of university-based teacher preparation programs in recent years, I have become even more committed to defending the work of schools of education, or at least those which are engaged in "rigorous, relevant and contextualized teacher preparation" (Taymans, et al., 2012, p. 242). In doing so, I accept responsibility for contributing to the improvement efforts of my local schools by preparing teachers *with*, not just in, these local schools and communities. I advocated for the inclusion of the term "with" in the title of Loyola University Chicago's recently redesigned teacher preparation program - *Teaching Learning and Leading **with** Schools and Communities* (TLLSC) – but little did I know how much this four letter word would continue to occupy my thoughts [see www.luc.edu/education]. Creating spaces for continued conversation about the meaning of teacher preparation in true partnership with schools and communities is the focus of this year's Crossroads proposal.

The TLLSC program is not alone in involving candidates in extensive clinical experiences. However, what is unique is the level of collaboration between the school of education and area schools, museums, parks, cultural and social service institutions, and local government offices. The program recognizes the critical importance of these partnerships in helping candidates to develop deep understandings about Chicago's diverse, metropolitan context. All partnerships have been purposefully forged around common goals related to meeting the needs of local schools and the birth-through-grade-12 students and families they serve. Partnerships have also been designed to utilize each organization's specific strengths as well as support areas of potential growth.

A necessary shift in thinking for faculty has been about the role that partners play in the program. Likeminded colleagues and I perceive partners serving as co-teacher educators. That is, unlike with more traditional clinical experiences, partners are not simply convenient host sites for candidates but instead have an opportunity to be active contributors to program design. With this level of involvement, partners are also rethinking their roles. School partners are beginning to see themselves as helping to introduce candidates to the intricacies of the teaching profession from the first weeks of their freshman year, as opposed to on the first days of student teaching or a first full-time job. Informal education partners are embracing the chance to meet and influence candidates early on rather than waiting to see them during in-service professional development programs.

How are stakeholders (including myself) making sense of these new roles? Has this indeed been a mutually beneficial experience? What are we (stakeholders) all learning about preparing teachers, about the various audiences we serve through our institutions, about other aspects of own work? Entering into the program's second year, my colleagues and I are engaging in self-study of our ongoing efforts to extend and strengthen these partnerships. Beyond logistical questions that are relevant to the evaluation and maintenance of the program, I am so curious to learn what else has been on partners' minds as we have entered into this, in many ways, uncharted territory.

The TLLSC program claims that it operates from the perspective that teaching itself is a form of inquiry (Tabachnick & Zeichner, 1999). Effective resilient teachers form a commitment to lifelong and collaborative questioning, investigation, reflection, knowledge generation, and dissemination (Cochran-Smith & Lytle, 2009). We have formed professional learning communities for candidates to participate in. But, what about the ongoing professional learning of faculty and partners? Would participating in a formalized professional learning community appeal to TLLSC partners? What might it entail? How might we support one another in taking an inquiry stance on our work as educators, and particularly within the varied contexts within which we work? How might we come together to demonstrate a commitment to re-examine, expand, and deepen our professional knowledge in pursuit of educational and social change? Could conversations such as those that take place within Crossroads-esque Incubator sessions help to "change the centre of gravity of teacher education programs" (Zeichner, 2006, p. 330) and deconstruct the common top- down, hierarchical nature of partnerships?

Lara Smetana
Loyola University – Chicago

AT THIS POINT MY VENTURE IS FURTHER ALONG THAN I ANTICIPATED. Moving beyond the initial brainstorming stage, folks have expressed their interest and begun committing their time and energy to this endeavor! Currently, we have outlined goals for our work as well as some initial research questions to pursue this year. A main concern now is to ensure that the initial momentum does not fizzle.

The theme of this year's conference could not have been more appropriate. I hope to find inspiration and guidance from others who have successfully created space for conversation and helped to support professional growth by using a Crossroads model as well as other collaborative formats. Foremost, I look forward to discussions about how this professional learning community could further enhance the WITH in our teacher preparation program. For instance, it is our intention that this newly forged learning community, comprised of faculty and informal education partners, be a venue where all people's voices are heard and used to productively inform each other's work and the future direction of the TLLSC program. The experience also needs to be constructed so that it continues to have personal and professional value to partners outside of academia.

Some discussion points:

- What different approaches to learning communities such as this have you taken? What pitfalls, successes, and words of wisdom might you offer?
- How have you introduced the Crossroads model to those who have not participated in these conferences? The format used for this conference, with a full paper that is written and revised, is somewhat unrealistic. At the same time, the chance to compose a thoughtful reflection and purposeful plan of action feels like a valuable component to try and incorporate. Where might I find a balance?
- Other practical questions occupy my thoughts. We are well aware that seeking outside funding will be necessary to ensure that the informal partners can continue to engage as co-teacher educators and as members of this professional learning community.
- My colleagues and I are eager to engage in open dialogue with others about this unique approach to teacher education, and to be able to write and present together with partners as we study the collective experience. We also feel it is important to disseminate the work in multiple venues, including non-academic ones? What opportunities have you had to do this? How might we approach this? What should we consider?
- Turnover in partner institutions is inevitable. How might we think proactively about the sustainability of our professional learning community initiative?

Point Not Taken: The Non-Emphasis of Science Education for Students with Disabilities

Jonte (JT) Taylor
The Pennsylvania State University

THE IMPORTANCE OF SCIENCE KNOWLEDGE FOR US STUDENTS has been stated in many reports, announcements, and declarations. Having a firm background in science knowledge has been connected to future workforce outcomes and employment in an advancing technological world (Terrell, 2007). Students need to have a grasp of science concepts beginning in early grades and ages. Unfortunately, equal press has been given to the fact that students in the United States are behind other economically advanced countries when it comes to international science assessments. As such, there has been a definite push to improve science outcomes within the context of science, technology, engineering, and math (STEM). Money, time, and resources have been used to support STEM and to address STEM related deficits for students.

For students with disabilities, particularly those who struggle in the areas of achievement and behavior, the benefits of the STEM push has not yet fully come to fruition. On national assessments of science, students with disabilities score significantly lower than their non-disabled peers. In science classes at all grade levels, these students do not find success in understanding science concepts or being engaged in science literacy. There is emerging support for STEM with students with disabilities but it is far behind supports for students without disabilities.

Not every aspect of STEM has been neglected for students with disabilities. Math has always been an area of emphasis for instruction. There are a number of strategies, techniques, and instructional supports strictly dedicated to math performance for students with disabilities. Traditionally, the focus on math skills (as well as reading) has been considered essential for students with disabilities. Research and resources have been poured into math education and math achievement for students who struggle. That same focus has not been given to the teaching and learning of science for those same students. ***For students with disabilities, learning science and science concepts is generally not considered as an important content area.***

The reason for the lack of attention to science education for students with disabilities can is varied. Kahn and Aronin (2013) noted that the incomplete training of pre-service teachers may contribute to the lack of science achievement for students with disabilities. Science teachers report being underprepared to teach students with disabilities (Kahn & Aronin, 2013). Conversely, special education teachers report either having a lack of preparation in teaching science or are not confident in their abilities to teach science curriculum (Kahn & Aronin, 2013; Patton, Polloway, and Cronin, 1990). While content area and elementary education pre-service teachers take at least one or two classes on students with disabilities, special education pre-service teachers usually do not take ANY courses on teaching science. ***The lack of emphasis on teaching science to students with disabilities as well as preparing pre-service teachers to teach science to these students has far reaching negative implications***.

THE FIELD OF SPECIAL EDUCATION HAS SEEN AN INCREASE in focusing on science education for students with disabilities. Over the past few years, journals dedicated to the teaching of students with special needs have had special issues devoted to science instruction and strategy. Additionally, science education journals have had issues dedicated to instructing students with disabilities under the theme of "Science for All." While these are all strides in the right direction, these periodic focuses on science instruction for students with disabilities still lack consistency and urgency. Educational research funding agencies have also started to direct resources towards improving instruction in science for students with disabilities. An increasing number of granting agencies are funding science related research and teaching projects specifically for students who traditionally struggle. These strides into making science literacy and understanding a more vital component in the education of students with disabilities is admirable and sorely needed, but ***they still lack the fundamental change in attitude*** that seems to be needed for the good of the future citizenry. If students with disabilities are left behind in the science portion of the STEM shift, some immediate consequences could include: fewer individuals prepared to work in advanced careers, decreased opportunities for financial independence and societal contribution, and the loss of different perspectives in the fields of science and technology.

In my short time of working in the field of science education, I have had to come to the realization that when I was a classroom teacher I was generally a poor science teacher. Occasionally, I stumbled upon a good lesson or two every few months, but for the most part I was a mediocre teacher of science content. As hard as that has been to admit, it has also become a humbling learning experience. Part of that humbling has come from the fact that it is possible that my training as a special education teacher may have contributed to my poor appreciation for science curriculum and my poor skill with instruction of that curriculum. There has been little solace in knowing that I am not in isolation in my science teaching experience. Actually, it has been a great catalyst in igniting my desire to do three core things. I would like to:

Jonte (JT) Taylor
The Pennsylvania State University

a) improve science outcomes for students with disabilities,

b) improve the training of both general education/elementary teachers and special education teachers in working with students with disabilities in science content, and

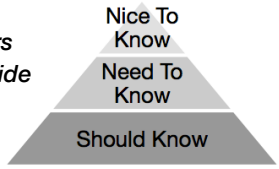
c) (which may be the trickiest part) convince teachers that emphasizing science for students with disabilities is not only a worthwhile pursuit but essential for increasing their likelihood of future life success.

I have personally started making strides to address holes in that intersection of special education and science education. From the special education side of things, I have started to advocate for the importance of teaching science education. I have also been hoping to influence others in understanding the utility of teaching science to students with disabilities in multiple ways. I have been encouraging special education teachers to use science instruction as more than just science instruction but also to incorporate reading and math. As most special education teachers worry about working on the goals and objectives associated with Individualized Education Program (IEP), I have been encouraging teachers to use science instruction as a means of working on the things in students' IEPs. For content area and elementary teachers, I have been providing tools and guidance on who to work with students with disabilities and how to make accommodations for all students. Lastly, I have developed tools to ease the stress of teaching science and/or teaching students with disabilities.

All in all, I am asking for assistance/suggestion on changing minds, hearts, and practices in answering these questions:

- What are some ways to increase the understandings of science and special education teachers' respective disciplines?
- What are some ways to encourage working with students with disabilities for science teachers?
- What are some ideas to explain or emphasizing the importance of science instruction to special education teachers?
- How can we promote the need for more special education classes for non-special education pre-service teachers and conversely, science teaching courses for special education pre-service teachers?

This diagram was created to improve communication between special educators and science educators at the elementary level. We created the diagram to provide focus and direction for students with special needs in science classes.



As part of the focus on professional learning and helping others develop their craft, with that craft being teaching students with disabilities. In that pursuit, I have tried to be involved in the following:

- Helping professional teaching organizations for both special education teachers and science teachers bridge the science instructional gap.
- Providing accessible supports directly to teachers to help with science teaching of students with disabilities;
- Developing science classroom tools and supports for teachers.
- Encouraging those teachers who "get it", that is, science teachers who actively engage students with special needs or special education teachers who understand the importance of science learning.

I have also included sample questions my team was encouraged to answer for that same group of teachers.

1. Since inquiry entertains all ideas, how can we help special ed. student takes inaccurate information as truth? Define teachers' role.
2. All students do not learn in the same style, so what are some methods to reach those struggling with SWH and inquiry philosophy?
3. When is it ok for the teacher to "give" information? Why is "giving" perceived as "passive learning"?
4. Do you have suggestions for when a student's self-esteem is impacted in a negative way by questioning to be more confident with negotiations?

Any ideas or direction would be greatly appreciated in this pursuit.

Networked Improvement Communities

Jessica Thompson, *University of Washington*

The 7th grade science lesson began with students explaining why a husky dog could have four pups each with slightly different fur coloring, including one with a distinct red coat. Lorena's interpreter tried to keep up with other students giving common language to five student-elicited hypotheses. Students moved from the whole-class conversation to partner work and Lorena rapidly tracked her interpreter's and her partner's hand movements. Her partner moved small pieces of paper, or "evidence slips," into three piles of supports/refutes/not applicable. Lorena took a stab at Hypothesis 3 about the role of the environment in determining phenotypic diversity. She signed that the environment did not change rapidly enough to change the genes of the red pup. Her idea was more sophisticated than what had previously been discussed by the class (or the designers of the lesson). By the end of the period her partner shared her idea in a whole-class conversation. Lorena rapidly signed as her partner and interpreter talked for her. She looked troubled and to the surprise of everyone in the class Lorena switched from sign language to English (her third language after Spanish). Unable to hear the sound of her own voice she loudly projected the idea about rapid environmental change within one generation. Silence fell as we—the four middle school science teachers, the district science and English Learner (EL) coaches, the principal, three university faculty and staff members, and 32 other students—recognized the great lengths Lorena had taken to help us advance our thinking about science and about what students are capable of. When debriefing the lesson, ***teachers and coaches credited the opening up of opportunities to participate in robust forms of reasoning****—for Lorena and others—****to the instructional changes we strategically made following the lesson we co-taught earlier in the day****.*

LORENA'S MIDDLE SCHOOL IS ONE OF EIGHT HIGH-POVERTY SCHOOLS engaged in our research-practice collaboration. We situate our work in high poverty schools and believe we have the most to learn from engaging with diverse communities — and the most to lose if we fail at delivering on the promise of quality teaching and learning. Collectively we aim to advance ambitious and equitable teaching and learning within and across schools. We refer to each school community with the multiple role actors listed above as a Local Improvement Network, or LIN. Lorena's middle school specifically is developing expertise around evidence-based explanations and how to support students in coordinating evidence with explanations. Other schools have taken up different dimensions of a core set of teaching practices that support NGSS (see tools4teachingscience.org). Each LIN helps fill gaps in ambitious and equitable teaching by specifying practices and investigating how and under what conditions they best meet the needs of all learners. The job-embedded professional development model at the heart of this project is informed by research on teacher learning and school reform (Ball & Cohen, 1999; Borko, 2004; Coburn, 2003; Kazemi, 2008). The model for each school includes Studio Days, coaching, and leadership support. Each school has 5-6 studios each year that bring together multiple role actors to co-plan, co-teach, and co-debrief. Coaching and leadership support are intended to link and support ongoing work between studios. Another critical component of our PD model is building mechanisms to share ideas not just within but also across LINs.

Bryk et al. (2011) argue that, while innovations abound in education, "there are no extant mechanisms to test, refine and transform practitioner knowledge into a professional knowledge base in education…the field suffers from a lack of purposeful ***collective*** action" (p. 5). They suggest that a diverse colleagueship of expertise is necessary to make progress and forward the work of teaching, not just teachers (Hiebert & Morris, 2012). The end-point of this project is not just improvements to individuals and schools but rather a networked system of shared knowledge and practices through which ideas can travel. Well-designed tools, school/department-wide job-embedded systems for professional development, and instructional leaders who can continue to support change in schools and districts are necessary for the network to grow and ideas to travel. This project draws upon successful knowledge-building and problem-solving systems, a model referred to as a *Networked Improvement Community* (Bryk et al., 2011; Englebart, 1992). Features of NICs include a focus on shared goals across the network and on improving visible, tangible, adaptable tools and practices. The network provides social structures that support participant inquiry around small tests of minor changes to practice and facilitates participant generated innovation throughout the system. Within the network ideas travel through at least three mechanisms that we can influence: through people (particularly coaches); through tools and tool use; through joint engagement within designed settings that bring stakeholders (students, teachers, and leaders) together.

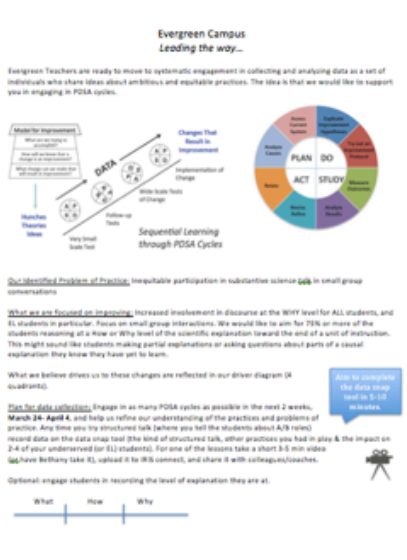
After one year all but one LIN has been successful in sharing ideas and developing common language around teaching practice. This is complex work that takes time and multiple opportunities for role actors to work elbow to elbow as they identify problems, name practices, and take risks together. There are many ways to improve the PD model to support the development of the NIC but I would like help thinking about two dimensions.

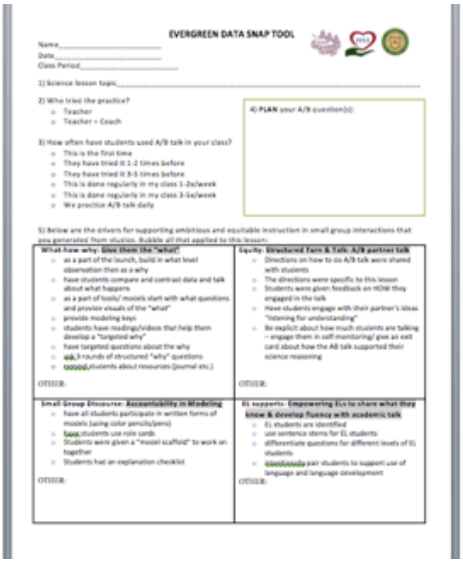
Jessica Thompson, *University of Washington*

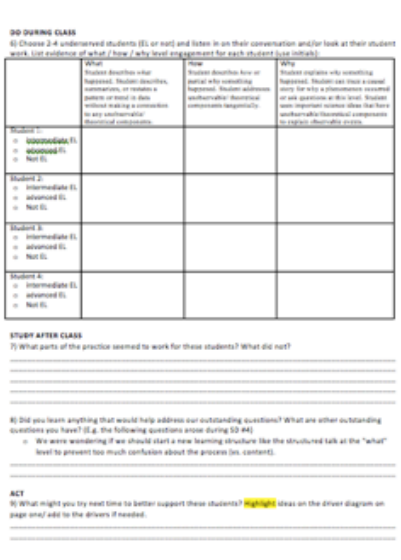
1) How do we support LINs in learning from one another in a way that maintains the embedded understanding of practice complex (and not reduced to individual teaching strategies)? Can this be done? How can we "package" and share tools, videos and histories of principled experimentation? Can this be done with a technological infrastructure?

2) Right now not all role actors are equal participants in co-designing and developing the work. The involvement of principals and district leadership is spotty but I would like help thinking about the role of students in the development of LINs. Right now students seem to be an object of study, that at times "prove" we are making progress and at other times highlight underlying assumptions about what students are capable of. Is there a way to better involve students as active participants in the professional development model?

NEXT FALL WE WILL ENTER INTO THE SECOND AND FINAL YEAR OF THE GRANT. We are learning about how to support LINs with developing a common vision of practice and are starting to develop a theory for how LINs engage in small tests of small changes depending on role actors' central/peripheral participation with the core practices and the social positioning of actors. We are seeing that LINs progress through three phases and sometimes cycle back and forth among phases. LINs new to the core practices are in a ***learning*** phase about the ambitious teaching practices and tools that have been developed by teachers and researchers over the past eight years. Their work is about "fit" and seeing how and where individuals can apply new ideas. Students supply images of what is possible in and across classrooms. Other LINs are in an ***incubation*** phase where they are testing sets of ideas collectively to see what supports student learning. Tools and practices are the object of study and students' written and spoken engagement function as barometers for changes. Lastly, some LINs are now in a ***testing*** phase. Teams are naming specific practices they believe are high leverage and are looking to see how many of the other co-occurring practices they have experimented with are critical to supporting the depth of students' scientific explanation. Teachers, coaches and university faculty co-develop **P**lan-**D**o-**S**tudy-**A**ct tools (adapted from Bryk et al. 2011) that are tested for 3 weeks at a time. We believe the development of these formative tools has promise for mediating the complex translation of practices from one LIN to another (or to individual teachers in the network). The PDSA tools might travel easily but we are seeing that teachers are more likely to try them first with a coach and that teachers and coaches rely on a rich history of experiences with the job-embedded PD to plan and enact lessons and discuss student learning with the PDSA tool. Could there be new uses for these tools that shift the role of students? How can we help suites of tools (tools for teaching, formative tools like the PDSA, and tools that empower students) and tool use travel within the network?







School Change for STEM Teaching And Learning: What does School Change Mean and for Who?

Bhaskar Upadhyay
University of Minnesota

> ***Superintendent***: *We want to start a five/six STEM school in our district. We want the university to help us "prepare" teachers to teach STEM to all student…We want teachers to be well versed in STEM.*
>
> ***Curriculum Specialist***: *We want all students to learn soft skills as well as content...we want teachers to think about and teach STEM…this is about school change from just a content to STEM.*

THE ABOVE VIGNETTE IS FROM AN EARLY CONVERSATION BETWEEN ME AND A SCHOOL DISTRICT in Minnesota about preparing 5/6 grade teachers for the new STEM school. From the vignette I inferred that the core belief among school leaders is that STEM teaching and learning has to be implemented in their schools. The change that the school is seeking is about some way to infuse engineering in their school curriculum with less emphasis on other content areas. Promotion of engineering at the cost of other content areas is a risk that is worth taking? I had not worked on school change the way the superintendent and the Curriculum Specialist were thinking and wanting to bring in their 5/6 grade school. However I have invested quite a substantial time in working with students, teachers, and parents from underrepresented groups. My research focus has been about understanding and supporting ways in which students and teachers from underrepresented groups could be engaged in science for better learning and better future. I have looked at school change through curricular change and rethinking of teaching and learning of science from a socio-cultural lens.

In this venture I (along with a group of students) provided professional development to the teachers at the 5/6 school. The goal of the professional development, as conceptualized by the school district leaders, was to build human capacity of the members of 5th and 6th grade STEM school teachers. Human capacity building was the key framework under which the school district wanted to pursue this professional development. The problem with human capacity framework is that is puts failure in the new system on the teachers, individuals who are uncertain of their own interest in being an STEM teacher. Thus the framework doesn't allow imagining STEM teaching and learning as a long term collective goal that needs to fit the values, culture, language, and experiences of the community where they teach (Tan, 2014). In order to create an environment for a much broader and collective engagement in building a STEM school, the professional development program lasted over a year focused on all STEM disciplines as well as the ways in which transdisciplinary teaching and learning could take place in the classrooms. I conceptualize transdisciplinary teaching and learning as a process where the connections between various disciplines (content areas and values) are more infused in a way that allows learners and teachers to engage in any activities in a seamless manner. For example: Students gain ability and insight into recognizing and appreciating connections between and among various content areas such as science, economics, culture, technology, history, and language etc. in a novel like the *Dragon Wings* by Laurence Yep (1975). The historical fiction *Dragon Wings* is not only about successful building of a kite using various scientific and technological knowledge but also about social, cultural, linguistic, immigration, economic, and oppressive experiences of Chinese immigrants in the nineteenth and early twentieth centuries. My conceptualization of transdisciplinary is about how knowledge and values from these different areas of human experiences and learning intersect seamlessly in understanding different contexts without having to discount one knowledge over the other or seeing knowledge and values from different disciplines to reside in only those disciplines or when engaged in those disciplines only. I see interdisciplinary to be more restrictive in the sense that the learner and the teacher is only interested in finding knowledge to be shared or used within the disciplines in action but not in any other ways. Therefore there was a clear departure, at least theoretically, from integration of contents to more seamless interactions among the disciplines. Another reason for choosing transdisciplinary framework was to make STEM teaching and learning experiences more inclusive for social-studies, language, arts, and music as they could equally contribute in a holistic and more productive learning engagement for all involved.

The participant included the administrator (principle), STEM school leadership team that comprised 12 teachers representing each of the disciplines at the school (science, mathematics, language, music, technology, and social studies) and 36 other teachers who would be teaching at the 5th and 6th grade STEM school. Our team provided monthly professional development for the leadership team with consultation and feedback after each of the professional development meetings. The leadership team had eight professional development meetings with us. During the all teacher professional development days, the members of the leadership team acted as facilitators in small group settings for discussions and activities but the research team led the overall professional development program. This set up provided means and opportunities for the school leaders and the leadership team to build their leadership capacities as well as own the learning that took place at all teacher professional development days.

Many schools and higher education institutions have framed STEM (Science, Technology, Engineering, and Mathematics) disciplines to provide important and growing opportunities for students in building 21st Century skills. Many documents argue that the 21st Century skills are about effectively and easily managing tasks of complex nature, problem solving, and systems thinking approaches (NRC, 2010). Furthermore recent framing of STEM education has been under the premise of economic gain by educating our youths for the 21st *century jobs*! As I have ventured into thinking about STEM education and school change to accommodate STEM, I am less inclined to think about STEM as an integration of four content areas. Additionally I am vehemently opposed to frame STEM education

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for the purposes of *Job preparation for the 21st Century*. I rather think about STEM more as a transdisciplinary engagement and educating youths for personal and social good rather than just economic good.

Another struggle a STEM initiative brings into a school setting is the loss of agency among non-STEM teachers and also students who are historically marginalized in these fields. For me agency is layered and is enacted in a layered fashion. There is not only personal agency, but there is communal agency too. STEM focus tends to make students from marginalized groups feel more powerless as they have to now figure out how their agency in STEM looks like and how they need to enact it. In order for schools to engage teachers and students in STEM fields, I am finding that the stake holders and the school leaders need to look at STEM initiative from the point of view of agency. Almost 40% of the students in this particular school district come from Hispanic, East African, and Hmong communities. However more than 95% the teachers are White who holds views about learning and academic success based on White-middle class norms. Therefore non-cognitive features of learning add to the further loss of agency among students from non-dominant groups. STEM adds to the woes of these students because now they have to succeed not only in science and math, a traditionally struggling content area for these groups, but also in engineering and technology. This brings me to my vexation about school change.

FIRST OF ALL THIS IS MY FIRST ATTEMPT TO VENTURE INTO A TRUE SCHOOL CHANGE INITIATIVE where everything is built from grounds up. The lessons learned from this experience and the data show that there are four key components in building and sustaining school change.

1. Attending to the non-cognitive features of STEM Education: What issues about agency and responsibility for students from marginalized groups get created and resolved?
2. Letting teachers experience what the students would potentially experience in the classroom: In building human capacity of teachers how do we engage them to struggle with the intersections of language, culture, history, and competing values that may disrupt the existing dominant norms and discourses.
3. Inquiry as access point for disciplinary teachers into the engineering process: What motivation do teachers have in learning engineering processes? Do they need to be experts to engage students in engineering activities?
4. Building leadership capacity: How do teachers see themselves as leaders in STEM teaching and learning when they are not considered to have a degree in one of the STEM fields?

However in this school I have found that the teachers who were non-science or math, they were equally engaged in ensuring that their content areas were a part of the STEM initiative at the school. For example using the historical novel ***Dragon Wings*** by Yep, teachers engaged students to bridge STEM content with historical fiction. Similarly drawings from the economics and budgeting, students were engaged in making important decisions about their scientific and engineering designs and the affordability of the products to people from different economic backgrounds. I see many very encouraging and valuable lessons that are coming out of this Venture, however, I need your help in several ways:

a. I want to tell a successful story about this school change experience in the context of STEM. However I don't want to leave the struggle of the teachers and the students in this change. If the school change is premised on the grounds of economic gain, then ***what does learning or engaging in STEM fields mean to students from marginalized groups and the teachers who teach non-STEM fields***?
b. ***How should school change initiative like this be theorized***? This brings tensions between the learners who come from underrepresented groups and the rest. ***Who are we trying to change and for what purposes***? I have very little understanding of literature and theories about school change. Any books, articles, research, will help.
c. What are some of the resources that would help me understand how school change should be conceptualized as building agency of students and teachers? ***Whose agency are we trying to preserve through STEM***? How does STEM treat agency where teachers and students who are not from those fields excluded? I am open to any suggestion.
d. In what ways I should think about STEM and human capacity building to make sense of what human capacity building means in the context of STEM initiatives? ***Does human capacity seem like a right way to theorize STEM initiative in a school district context***?

I am open to any suggestion that would aid me in understanding and conceptualizing school change and how school change research is carried out.

Nature of Technology Benchmarks for the Design, Development, Implementation and Enactment of Science Education Technologies

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THE PURPOSE OF THIS VEXATION IS TO FORMULATE A SET OF BENCHMARKS OR CRITERIA that will be used to evaluate (and critique) how dimensions of nature of technology (NoT) (Waight & Abd-El-Khalick, 2012) are ***realized*** in the design, development, implementation and enactment of technologies in science classrooms. More specifically, the benchmarks will serve as a guide to determine if and how dimensions of NoT are realized in (a) the design and development of science educational technologies (b) importation of technologies from other contexts (e.g. scientific research, gaming) into the science education context (c) curriculum development that involve technology integration (d) classroom enactment of technologies (e) teacher and student experiences with technologies and (f) teacher and student learning and understanding in the context of technologies. Science education technologies refer to the artifact and its associated documents, practices and interactions.

Efforts to establish benchmarks to evaluate dimensions of NoT are informed by theoretical and empirical work on implementation of technologies in precollege science classrooms (Waight & Abd-El-Khalick, 2011); the role of teacher knowledge of technology for science teaching (Waight, 2013) and understandings of the cycles of technology development, deployment and extinction (Waight, Chiu & Whitford, 2014). Much of the underlying framework for the above work is embedded in understandings of philosophy of technology [PoT] (Illich, 1973; Pacey, 1983 Ellul 1964; Tenner, 1996; Mitcham, 1994) and the history and sociology of technology (Basalla, 1996; Clark, 2003; Volti, 2010). The PoT literature established that technologies impact and are impacted by a conglomerate of factors broadly attributed to dimensions of society: individuals, society, institutions, economy, politics, and culture (e.g. Ellul, 1964; Heidegger, 1977; Pacey, 1983; Tenner, 1996). Based on our own work in the context of science education we identified 5 dimensions that are characterized by culture and values; understandings of notions of technological progression; technology as part of systems; technological diffusion; technology as a fix; and notions of knowledge and expertise (Waight & Abd-El-Khalick; 2012). We argue that understandings of these dimensions determine realizations of technology in the process of design, development, and implementation.

Evidence from our own research work revealed that conceptions and experiences of, and with technology tend to emphasize traditional and rigid expectations, and reflect incomplete understandings of how technologies are realized in context. For example, in one study we examined high school science teachers' knowledge of technologies in their own practice and the findings indicated that teachers hold conceptions that emphasize technology as artifact, overwhelming optimism on the purpose of technology to make life easier, and technology representing advancements in civilization. In another study we investigated science teachers' selection and usage of technologies in high school science classrooms. The findings revealed that science teachers were more likely to use instructional tools such as clickers and SMARTboards and laboratory tools such as probeware. In sum, NoT analysis of these studies revealed that limited understandings impacted selection and use of technologies for science teaching and learning.

DISCUSSION OF NoT IN the science education literature often prompt the questions: How do we identify when and how dimensions of NoT are visible or alternatively lacking in science education practice, i.e., in the process of design, development, deployment and enactment of technologies? What is it that stakeholders, teachers and students need to know and do? With this in mind I propose conducting empirical research and analysis of literature related to the full process of technology design, development, deployment and enactment. This would involve compiling scenarios (a) of different ***models of science education design***

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and development (b) that identify the ***roles of designers and developers*** **(c) that describe** implementation and enactment of ***similar technological tools in different contexts*** and, different technological tools in different contexts and, (d) that identify ***teachers and students' roles*** in the full process. Below I provide an example of how the full process would unfold in the context of design, development and implementation of a gaming interface. The assumption is that these scenarios will yield a set of benchmarks or criteria that represent understandings, or lack of, of NoT. So, evidence from these scenarios can be used to initiate models of "best practice".

In light of the the above, it would help to receive feedback on the following:

1. The research approach described above.
2. What other scenarios could contribute to our understandings of NoT in design, development, implementation and enactment?
3. Are there other suggestions to operationalize NoT in the context of teaching and learning?
4. What would be the appropriate methodological approach to systematically interrogate aspects of design, development, implementation and enactment?
5. What would be the best order to interrogate these issues? In other words, should I first investigate the process of design and development and follow up by investigating implementation and enactment? Or would it be more fruitful to engage the reverse process?

I envision that models of "best practice" of NoT would serve researchers evaluating various aspects of technology implementation in science classrooms; would inform teacher preparation; would allow teachers and students to evaluate which tools best serve their teaching and learning needs; and can serve as a template for science departments, administrators and associated stakeholders to evaluate the alignment of new technologies with teaching and learning goals.

An Example of a Scenario

The full process described above would entail examining the models and thought process of design and development of science education technologies. For example what is the background knowledge, motivations and expertise involved in laying out of a design plan for an educational gaming interface. Are these design plans embedded in theory or practice? Who is involved and why? What are the roles of the designers and developers? What expertise contributes in bringing the gaming interface to fruition? How is usability and suitability (e.g. for grade level, context of learning, student background etc.) determined? Once the gaming interface is introduced into the classroom setting, how are schools and the classroom readied for this implementation? What does a teacher and students do? What is the nature of the instructional approach, instructional techniques and assessment in the context of this implementation? What are the teaching and learning outcomes? How do students perceive this experience and why?

I can't be an Octopus, but I do have a Garden: How can we transition a school garden from being Ours (university faculty) to being Theirs (local rural school)?

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HOW CAN WE SUPPORT TEACHERS TO DEAL WITH THE COMPLEX SITUATION in their schools, while encouraging them to teach a subject that their students love and is relevant to their lives? How can we balance our enthusiasm for the potential that school gardens hold as a learning context that open up new possibilities for learning, but is inherently unpredictable, takes a LOT of work, and is "extra?"

Over the last year, our teachers in the state of North Carolina have been bombarded by changes that strip them of support, professionalism, and for many, enthusiasm for teaching. Our teachers in North Carolina had no financial incentives to pursue advanced degrees in their fields, had had no significant pay raises in at least 5 years, were being asked to compete with their peers for a $500 pay raise available only to the top 25% of their staff, but if they accepted it, they would give up their tenure for a 4 year contract. This is the situation which our elementary teachers were facing this past year. The pay raise for tenure swap was declared unconstitutional by at state Superior Court judge and over the summer, the state legislature passed a pay raise for teachers that heavily favors younger teachers (in their first ten years), but includes a pay raise for all teachers.

Amidst these influences, a colleague of mine, Leslie Bradbury, and I have been helping local elementary teachers at a rural K-8 school in our county write grants to implement a school garden. We have been successful in getting money to provide garden supplies for seven raised beds, seeds for food plants and seedlings of native plants, tools, fencing, cold frames, and a shed. We have been able to teach integrated language arts and science lessons in grades K, 1, 2, 3, and 5 that are tied to the school garden and to grade-level state science standards.

Leslie and I have heavily invested our time in getting the school garden project off the ground. We realized that starting a meaningful partnership with the teachers at this elementary school was going to be critical to the success of the project. We knew that many of the teachers at the elementary school spend less time (or no time) teaching science due to pressures to have students succeed on reading and mathematics assessments. Yet when we recently interviewed these same teachers, they all expressed an enthusiasm for the subject and shared that their students were equally as excited about science. We decided that we were not only going to provide labor to start the garden, but also plan and teach lessons to help the teachers see the possibilities for teaching science topics related to the garden, as well as for integration of garden topics into their language arts lessons. Leslie and I brought university students to help build the garden structures. We visited classrooms individually to teach model lessons related to garden topics that integrated inquiry-based science and language arts standards. We invited classes of elementary students to work in the garden in the fall, and to plant seeds with us in the garden this spring to test various environmental factors to see how they influenced plant growth. And we are now overwhelmed with the amount of time we spend planning, visiting classrooms, and working in the school garden. We have realized firsthand why the little research that has been done on school gardens has found that having a dedicated garden coordinator at the school is key to the garden's success (Blair, 2009).

We strongly believe in the potential that the school garden holds as a relevant learning context for these rural students. Already, we have anecdotally been speaking with teachers about their students' responses, and how much enthusiasm they see in their students for all of the lessons related to the garden. We believe it is important to support the teachers in finding time to teach science as inquiry, to use the garden as a context to integrate local agricultural culture and history, and to incorporate science reading and writing activities into their language arts curriculum. Yet, Leslie and I are both faculty members with more than a 2-2 teaching load, and we are torn between our responsibilities at the university and at the elementary school because we both value our time with the teachers and elementary students. We are both feeling a bit short-handed in terms of what we can do, but more importantly, how long we can continue all that we are doing.

We realize that in trying to take on the garden ourselves for the school in an effort to gain teacher support as we showcase what is possible, we have potentially made the garden appear more our own than the school's own. This is our vexation with ourselves: that our good intentions for helping the project move forward have put us in a tight spot where we need to be an octopus with eight arms in order to manage the school garden, elementary science teaching, university teaching, research, and service, and….

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Therefore, our questions are:

- How do we transition our school garden project to feel like theirs and not ours?
- How can we empower teachers in such a constraining professional situation to use the garden as a creative outlet to develop their identities as professional elementary teachers of all subjects (with a focus on science)?
- How can we get the school staff and community more involved so that we can be support, but not the octopus?

OUR ATTEMPTS TO SET-UP AN ELEMENTARY SCHOOL GARDEN, provide initial maintenance through the use of pre-service teachers in my service-learning course, plan and teach integrated language arts and science lessons have been successful in terms of developing teacher and elementary student enthusiasm for the garden. Now we would like to start a transition to making the garden more of their own project. We are hopeful that due to the garden implementation, we will have more time to work with teachers on curriculum planning. In addition, Leslie will be on off-campus scholarly leave in the spring of 2015 with the intention that she will spend multiple mornings each week at the school to work with teachers and students. I will list our venture ideas as a timeline.

School year 2014-2015:

- Co-plan (Leslie and Rachel and teachers) and co-teach (Leslie and teachers) garden-related language-arts and science lessons in grade level classrooms
- Develop a professional development plan for teachers in the project for in the school year to help modify the integrated garden lessons, as well as create new lessons
- Create a school garden advisory board with principal and teachers to decide future directions for garden planting, maintenance in summer, and grant writing
- Invite local experts on agricultural topics to advise teachers and elementary students on inquiry projects they could work on that are garden related
- Arrange community workdays to encourage community participation in and support for garden maintenance
- Meet with school PTA to identify parents with garden expertise to encourage their participation in the project

Further down the road:

- Co-Create (with teachers) a curriculum booklet organized by grade level with lessons tied to state science and Common Core English Language Arts standards with extensions for integrating other subjects (math and social studies) and trade books to be used with that topic area
- Write a grant to fund a school-based garden coordinator
- Gather local knowledge about gardening (oral/ethnographic research project) using undergraduate students to provide a written resource for classroom teachers and in the school library

Leslie and I feel fortunate that we have been able to find a project that helps us improve our courses with preservice elementary teachers, provides a service to local teachers and students, as well as provides a context for our research. We would appreciate your feedback on how to approach pulling out of the day-to-day garden tasks in order to focus more on professional development for teachers and our research goals.

Teachers as Teacher Educators: Building Capacity for Change Through Teacher Leadership

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IN RECENT YEARS THERE HAS BEEN INCREASED ATTENTION to integrating scientific discourse and practices into school science (National Research Council, 2012). In particular, contemporary perspectives on proficiency in science highlight the centrality of constructing, interrogating, and using scientific explanations, as well as participating in argumentation (Duschl, Schweingruber & Shouse, 2007; Osborne, 2012). This emphasis is grounded in research that demonstrates students learn scientific practices best when using their knowledge while participating in the practices of the discipline (Lehrer & Schauble, 2000, 2004, 2005; Metz, 2004). Moreover, research has demonstrated that children are capable of fairly sophisticated forms of scientific reasoning (Metz, 1995).

Although there is potential to achieve proficiency in science, the current state of teaching, curriculum, assessment, and standards do not support students' understanding of core ideas in science or engage them in scientific discourse and practices. Furthermore, with the goal of intertwining the strands of core disciplinary ideas, crosscutting concepts, and scientific and engineering practices, the Next Generation Science Standards (NGSS) (2013) have rendered many experienced teachers novices. Thus, professional development of teachers at all levels (e.g., elementary, middle, high school) and stages of the professional learning continuum (e.g., preservice, novice teachers, veteran teachers) is more necessary than ever.

A perennial problem we continue to face in the era of NGSS is ***what counts as effective professional learning opportunities for teachers***? In many ways, we know more about what does not work than what is effective in terms of professional development. There is general agreement in the field that we should avoid professional development that is "learning theory light," discrete/unconnected, and decontextualized. A consensus perspective for effective professional learning has emerged – focus on science content and pedagogy; active and collaborative engagement of teachers; links to curriculum; analysis of teaching practice and student work; sustained over time. However, research on these proposed pillars of effective professional learning opportunities is limited and somewhat mixed in terms of results.

Another lingering problem that seems especially relevant in light of the need created by NGSS is the question of who is responsible for the professional development of teachers in science – what should they know and be able to do in order to be effective? If having excellent teachers is such an important aspect of children's learning, then shouldn't having excellent professional development providers be equally important to teacher learning and development? In the field, various perspectives on this problem are being proposed. For instance, there are those who assert that professional development providers for teachers in science should have school science teaching experience and a proven track record of working with students in ways that reflect NGSS. Unfortunately, this is an area about which we know even less than what is required for effective professional development.

GIVEN MY WORK IN A K-5 PROFESSIONAL DEVELOPMENT SCHOOL (PDS) SETTING, I have come to understand the power of teachers as teacher educators. In our PDS context, teachers collaborate with university faculty in co-teaching methods courses for preservice teachers. The synergy is undeniable, and contributions of the classroom teachers are essential to new teacher learning in science. For example, teachers bring samples of their students' work and often video of their classroom science teaching for preservice teachers to analyze. Their knowledge of students and the curriculum allows for insights that would not be possible otherwise. The teachers who assist with science methods have participated in their own professional development in science over the course of many years through involvement with funded projects focused about engaging students in constructing explanations from evidence and scientific argumentation. The university faculty who collaborate with these teachers have worked alongside them in their elementary classrooms. Both teachers and university faculty are accomplished with engaging children in scientific discourse and practices in the service of learning science.

Although it is unlikely to "scale" in significant ways, I have often wondered what can be gleaned from the PDS approach that would allow us to reach more preservice and practicing elementary teachers. We know that "train the trainers" models for professional development are typically unsuccessful, in part because we assume [often incorrectly] that teachers have the understandings and pedagogy to return to their schools and teach

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their peers/colleagues. How might we craft opportunities to develop teacher leaders who are both skilled at supporting students' meaningful science learning and scientific practices, as well as at supporting the professional learning of their peers?

My colleagues and I are currently working with groups of lead teachers in elementary science from three different states. To date, the focus has been on their professional learning for supporting students in constructing evidence-based explanations in science. Two experienced classroom teachers from the PDS are part of the instructional team. Given that many teachers have not experienced learning science in the ways advanced by NGSS, our approach has been to engage K-5 teachers as learners in model lessons that give priority to evidence and explanation, as well as classroom discourse. We analyze each of these lessons as a group, introducing appropriate learning theory and pedagogical approaches as we go. Next we analyze video of science teaching in the context of similar lessons taught in K-5 classrooms and examine samples of student work. In this way, teachers come to see how student learning is supported through participation in scientific discourse and practices. We provide support for teachers to develop a plan for science instruction before returning to their classrooms to implement it. Then we come back together and analyze teachers' practices and samples of student work. This phase typically follows several cycles and may involve co-teaching with someone from the instructional team.

In the past, we have expanded our efforts by bringing new teachers into the group. However, I am wondering about intentionally building a professional learning component focused on how the teachers in the leadership group might return to their schools and build capacity for science teaching with their colleagues. The model my colleagues and I are considering involves another layer of professional development for the teachers with whom we are working. This layer should sound familiar in terms of our approach to introducing teachers to supporting students' scientific discourse and practices. For the pilot, we plan to invite participation from an group of 5th grade teachers in the PDS who are spending the Fall 2014 semester reviewing and revising ecosystems unit from their curriculum. The aim is to include opportunities for students to engage around interesting phenomena and construct explanations from evidence in ways that allow for participating in scientific practices and learning deeply disciplinary core ideas. To do this, we will be addressing all three dimensions of NGSS with teachers as learners and teachers as fundamental architects for supporting children's meaningful learning (as described previously).

Once the 5th grade teachers have had the opportunity to implement the revised unit and new approaches to teaching science in their classrooms, as well as collaboratively analyze their teaching, the aim is to include them in planning professional learning opportunities for their peers (those who were not part of the initial PD). Since they will have recently experienced the perspective of learner, we can unpack the PD experience from new perspectives, and introduce underlying learning theory and conceptual constructs of teacher leadership and teacher learning. The group will co-construct plans for returning to their schools and supporting the learning of their colleagues, most likely in a professional learning community (PLC) setting. The leadership group will come back together throughout this period and analyze their coaching using artifacts, such as video of the PLC interactions and samples of teachers' work (e.g., writing scaffolds for explanation-building, lesson plans). Our goal at this stage is to examine "proof of concept" for extending a powerful PD model for science teaching to teacher leadership in science. We are currently building a research agenda around the pilot implementation, which will necessarily involve the learning and practices of the teacher leaders, as well as the science learning and teaching practices of their peers. In doing this work, we hope to also address the question of where expertise resides – a concern that has been raised in the literature about organically organized, school-based, PLCs.

It is important to note that one of the barriers to this kind of work is lack of support from school and district administrators. In our case, a former principal of an early PDS adoption school has become the K-6 curriculum director for the school district. In this role, she is both knowledgeable about the work with students and supportive of our work with teachers. We recognize this ally as an asset that others may not initially have in place, but is crucial to the success of exploratory work with teachers.

Citations

Abedi, J., & Lord, C. (2001). The language factor in mathematics tests. *Applied Measurement in Education, 14*(3), 219-234.

Abell, S. K., & Siegel, M. A. (2011). Assessment literacy: What science teachers need to know and be able to do. In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), *The professional knowledge base of science teaching* (pp. 205-221). Springer Netherlands.

Achieve, Inc. (2013). *Next Generation Science Standards*. www.nextgenscience.org/next-generation-science-standards

Afterschool Alliance. (2009). *America after 3pm*: *A household survey on afterschool in America*. Washington, DC. http://www.afterschoolalliance.org/AA3PM.cfm

Baldwin, J. (1963/1993). My dungeon shook: Letter to my nephew on the hundredth birthday of the Emancipation. In *The Fire Next Time* (pp. 1-10). New York: Vintage Press.

Balgopal, M.M., McMeeking, L. B., Howe, J., Winey, T., & Nielsen, S. (2014). *"The meme-ing of STEM."* Paper presented at the Annual National Association of Researchers in Science Teaching, Pittsburgh, PA.

Ball, D. L. & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3-32). San Francisco: Jossey-Bass.

Banilower, E. R., Heck, D. J., & Weiss, I. R. (2007). Can professional development make the vision of the standards a reality? The impact of the national science foundation's local systemic change through teacher enhancement initiative. *Journal of Research in Science Teaching*, *44*(3), 375-395.

Basalla, G. (1996). *The evolution of technology*. New York, NY: Cambridge University Press.

Bell, D. (1987). *And we are not saved: The elusive quest for racial justice*. New York, NY: Basic Books.

Bell, D. (1991). The Hegelian secret: Civil society and American exceptionalism. In B. E. Shafer (Ed.) *Is America different: A new look at American exceptionalism* (pp. 46–70). New York: Oxford University Press.

Bell, D. A. (1992). *Faces at the bottom of the well: The permanence of racism*. New York, NY: Basic Books.

Blair, D. (2009). The child in the garden: An evaluative review of the benefits of school gardening. *The Journal of Environmental Education*, *40*(2), 15-38.

Blumer, H. (1969). *Symbolic interactionism: Perspective and method*. Englewood Cliffs, NY: Prentice Hall.

Board on Science Education. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington D.C.: National Academies Press.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Borko, H., Jacobs, J., Eiteljorg, E., & Pittman, M. (2008). Video as a tool for fostering productive discussions in mathematics professional development. *Teaching and Teacher Education*, 24(2), 417–436.

Bradburne, J. (1998). Dinosaurs and White Elephants: The science centre in the 21st Century. *Museum Management and Curatorship, 17*(2), 119–137.

Brosio, R. A. (1994). *A radical democratic critique of capitalist education*. New York: Peter Lang Publishing.

Brown, B. A., Reveles, J. M., & Kelly, G. J. (2005). Scientific literacy and discursive identity: A theoretical framework for understanding science learning. *Science Education*, *89*, 779-802.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*, 32–42.

Bryk, A. S., Gomez, L. M., & Grunow, A. (2011). Getting ideas into action: Building networked improvement communities in education. In Maureen Hallinan (Ed.), *Frontiers in Sociology of Education*, New York, NY: Springer Publishing. http://www.carnegiefoundation.org/sites/default/files/bryk-gomez_building-nics-education.pdf

Bullough, R. V., & Pinnegar, S. (2001). Guidelines for quality in autobiographical forms of self-study research. *Educational Researcher, 30*(3), 13-21.

Butler, J. (1999). *Gender trouble.* NY: Routledge.

Campbell, T., ZuWallack, B. A., Longhurst, M., Shelton, B. E., & Wolf, P. G. (2014, January). An examination of the changes in science teaching orientations and technology-enhanced tools for student learning in the context of professional Development. *International Journal of Science Education*. First published online 21 January 2013.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*, 1187-1218.

Carlone, H.B., Huffling, L., Tomasek, T., Hegedus, T., & Matthews, C. (April, 2014). *Promoting identity boundary work in a summer field ecology enrichment program for diverse youth*. Paper at AERA, Philadelphia, PA.

Cavagnetto, A., Hand, B. M., & Norton-Meier, L. (2010). The nature of elementary student science discourse in the context of the science writing heuristic approach. *International Journal of Science Education, 32*(4), 427–449.

Coburn, C. E. (2003). Rethinking scale: Moving beyond numbers to deep and lasting change. *Educational Researcher, 32*, 3-12.

Cochran-Smith, M., & Lytle, S. L. (1999). The teacher research movement: A decade later. *Educational Researcher, 28*(7), 15-25.

Coia, L., & Taylor, M. (2009). Co/autoethnography: Exploring our teaching selves collaboratively. In D. L. Tidwell, M.L. Heston, & L.M. Fitzgerald (Eds.), *Research methods for the self-study of practice*. (pp. 3-16). Dordrecht: Springer.

Cook, S. D. N. and Brown, J. S. (1999) Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organization Science*, *10*(4), 381-400.

Counts, G. S. (1932/1978). *Dare the school build a new social order*. Carbondale: Il: Southern Illinois University Press.

Counts, G. S. (1946). Soviet version of American history. *Public Opinion Quarterly*, *10*(3), 321-328.

Cowan, R. (1999). *More work for mother: The ironies of household technology from the open heart to the microwave*. New York: Basic Books.

Cress, D. M. & Snow, D. A. (2000). The outcomes of homeless mobilization: The influence of organization, disruption, political mediation, and framing. *American Journal of Sociology*, *105*(4), 1063-1104.

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

Du Bois, W. E. B. (1903/1996). The talented tenth memorial address. In Gates, Jr., H. L. & West, C. *The future of the race*, pp. 133 – 157. New York, NY: Vintage.

Du Bois, W. E. B. (1948/1996). The talented tenth. In Gates, Jr., H. L. & West, C. *The future of the race*, pp. 159 – 177. New York, NY: Vintage.

Eckman, J. (2011, June 18). Ayn Rand and Christianity. *Issues in perspective with Dr. Jim Eckman*. Retrieved from http://graceuniversity.edu/iip/2011/06/18-1/ on April 23, 2014.

Eisner, E. W. (1975/2002) The three curricula all schools teach. In Eisner, E. W. *The educational imagination: On the design and evaluation of school programs*, 3rd Ed., pp. 87 – 109. Upper Saddle River, NJ: Prentice Hall.

Ellul, J. (1964). *The technological society.* Canada: Alfred A. Knopf.

Endedy, N., Goldberg, J., & Welsh, K. (2005). Complex dilemmas of identity. *Science Education*, *90*, 68 – 90.

Englebart, D. C. (1992). *Toward high-performance organizations: A strategic role for groupware*. Groupware '92. San Jose, CA: Morgan Kaufman Publishers.

Fishman, B., Penuel, W. R., Allen, A., & Cheng, B. H., & Sabelli, N. H. (2013). Design-based implementation research: An emerging model for transforming the relationship of research and practice. In B. Fishman, W. R. Penuel, A. Allen, & B. H. Cheng (Eds.) *Design-based implementation research: Theories, methods, and exemplars*. National Society for the Study of Education Yearbook (vol. 112(2), pp. 136-156). New York: Teachers College Record.

Fleischman, P., & Beddows, E. (1989). *Joyful Noise: Poems for Two Voices*. Harper Collins.

Freire, P. (1970/2000). *Pedagogy of the oppressed*, 30th Anniversary Edition. New York, NY: Continuum.

Fullan, M. & Miles, M. (1992). Getting reform right: What works and what doesn't. *Phi Delta Kappan*, *73*, 744-752.

Fullan, M. (2001). *Leading in a culture of change*. San Francisco: Jossey-Bass.

Fuller, F. F. (1969). Concerns of teachers: A developmental conceptualization. American Education Research Journal, 6, 207-226.

Giamellaro, M. (2014). Primary contextualization of science learning through immersion in content-rich settings. *International Journal of Science Education*. Published online July 15. DOI:10.1080/09500693.2014.937787

Giglio, B. (2006). Chapter 15: Developing professional learning communities. In Rhoton, J. & Shane, P. (Eds.), *Teaching science in the 21st century* (pp. 231-242). Arlington, VA: National Science Teachers Association.

Gilbert, A. (2013). *Courageous pedagogy: Enacting critical science education*. Charlotte, NC: Information Age.

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

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 15–46). New York: Simon & Schuster Macmillan.

Grossman, P. L., Smagorinsky, P., & Valencia, S. (1999). Appropriating tools for teaching English: A theoretical framework for research on learning to teach. *American Journal of Education*, *108*(1), 1-29.

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.

Citations

Grossman, P., Hammerness, K., & McDonald, M. (2009). Redefining teaching, re-imagining teacher education. *Teachers and Teaching, 15*(2), 273–289.

Hammer, D., Elby, A., Scherr, R. E., & Redish, E. F. (2005). Resources, framing, and transfer. In J. P. Mestre (Ed). *Transfer of learning from a modern multidisciplinary perspective* (pp. 89–120). Greenwich, CT: Information Age Publishing.

Hand, B. (2008). *Science inquiry, argument, and language: A case for the Science Writing Heuristic Approach*. Rotterdam, The Netherlands: Sense Publishers.

Heidegger, M. (1977). The question concerning technology and other essays. New York: Harper & Row.

Herrnstein, R. J., & Murray, C. (2010). *Bell curve: Intelligence and class structure in American life*. New York, NY: Simon and Schuster.

Hiebert, J., & Morris, A. K. (2012). Teaching, rather than teachers, as a path toward improving classroom instruction. *Journal of Teacher Education, 63*(2), 92-102.

Horn, I. S., & Little, J. W. (2009). Attending to problems of practice: Routines and resources for professional learning in teachers' workplace interactions. *American Educational Research Journal*, 47(1), 181–217.

Illich, I. (1973). *Tools for conviviality.* New York: Harper & Row.

James, M. (2014). *Facing current issues in urban education: Race, class, and gender*. Paper presented at the annual meeting of AERA, April 3-7, Philadelphia, PA.

Johnson, A. (2007). Orchestration of science education adventurism. Keynote address. Science Education at the Crossroads.

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher, 38*(5), 365–379.

Kahn, S. & Aronin, S. (2013). *A call for collaboration and training to support 'science for all'.* NSTA WebNews Digest. Last retrieved 4/26/2014 from http://www.nsta.org/publications/news/story.aspx?id=59873.

Kazemi, E. (2008). School development as a means to improve mathematics teaching and learning: Towards multidirectional analyses of learning across contexts. In K. Krainer & T. Wood (Vol. Eds.). *Participants in mathematics teacher education: Individuals, teams, communities, and networks* (pp. 209-230). In T. Wood (Ed.), International handbook of mathematics teacher education: Vol.3. Rotterdam: Sense Publishers.

Kazemi, E., & Hubbard, A. (2008). New directions for the design and study of professional development: Attending to the coevolution of teachers' participation across contexts. *Journal of Teacher Education*, 59(5), 428–441.

Kazemi, E., Franke, M., & Lampert, M. (2009). Developing pedagogies in teacher education to support novice teachers ' ability to enact ambitious instruction. In R. Hunter, B. Bicknell, & T. Burgess (Eds.), *Crossing divides: Proceedings of the 32nd annual conference of the Mathematics Education Research Group of Australasia* (Vol. 1).

Klein, E. J., Taylor, M., Onore, C., Strom, K., & Abrams, L. (2013). Finding a third space in teacher education: Creating an urban teacher residency. *Teaching Education*, *24*(1), 27-57.

Lampert, M. (2009). Learning teaching in, from, and for practice: What do we mean? Journal of Teacher Education, *61*(1-2), 21–34.

Lee, O., Maerten-Rivera, J., Penfield, R., LeRoy, K., & Secada, W. (2008). Science achievement of English language learners in urban elementary schools: Results of a first-year professional development intervention. *Journal of Research in Science Teaching, 45*(1), 31-52.

Lehrer, R., & Schauble, L. (2000). Developing model-based reasoning in mathematics and science. *Journal of Applied Developmental Psychology*, *21*(1), 39-48.

Lehrer, R., & Schauble, L. (2004). Modeling natural variation through distribution. *American Educational Research Journal*, *41*(3), 635-679.

Lehrer, R., & Schauble, L. (2005). Developing modeling and argument in the elementary grades. *Understanding mathematics and science matters*, 29-53.

Lincoln, A. (1858/2004) Fourth Debate: Charleston, Illinois: September 18, 1858: Mr. Lincoln's Opening Speech. In H. Holzer (Ed.). *The Lincoln-Douglas debates: The first complete, unexpurgated text*, n.p. New York, NY: Fordham University Press.

Lincoln, A. (1860/2012). *Speech at New Haven*, March, 6, 1860. In Abraham Lincoln: Speeches & Writings 1859-1865: Library of America # 46. Library of America

Lortie, D. C. (1975). *Schoolteacher: A sociological study*. Chicago: The University of Chicago Press

Luft, J. A., Wong, S. S., & Semken, S. (2011). Rethinking recruitment: The comprehensive and strategic recruitment of secondary science teachers. *Journal of Science Teacher Education, 22*(5), 459-474.

Lumpe, A. (2007). Research-based professional development: teachers engaged in professional learning communities. *Journal of Science Teacher Education, 18*(1), 125-128.

Lundh, P., House, A., Llorente, C., D'Angelo, C.M., Harris, C.J., Leones, T. (2014). *One Activity at a Time: The Role of Instructional Materials in Afterschool Science.* Paper presented at the National Association for Research in Science Teaching, Pittsburgh, PA.

Lyon, E. G. (2013). Learning to assess science in linguistically diverse classrooms: Tracking growth in secondary science preservice teachers' assessment expertise. *Science Education, 97*(3), 442-467.

MacMahon, A. M. (1935). Science and the Recovery Program. *The Scientific Monthly, 40(*1), pp. 77–80.

Malone, K. & Barabino, G. (2009). Narrations of race in STEM research settings: Identity formation and its discontents. *Science Education*, *93*, 485 – 510.

Mckenney, S. & Reeves, T. C. (2012). *Conducting educational design research*. Abingdon: Routledge.

Mead, G.H. (1962). *Mind, self and society: From the standpoint of a social behaviorist*. Chicago: University of Chicago Press.

Metz, K. E. (1995). Reassessment of developmental constraints on children's science instruction. *Review of Educational Research*, *65*(2), 93-127.

Metz, K. E. (2004). Children's understanding of scientific inquiry: Their conceptualization of uncertainty in investigations of their own design. *Cognition and Instruction*, *22*(2), 219-290.

Mitcham, C. (1994). Thinking through technology: The path between engineering and philosophy. Chicago: University of Chicago Press.

National Commission of Science and Mathematics Teaching for the 21st Century (2000). *The Glenn Commission Report: Before it's too late*. Washington, DC: Author.

National Research Council [NRC]. (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics.* National Academies Press, Washington, D.C.

National Research Council. (1996). *National Science Education Standards*. Washington, D.C.: National Academy Press.

National Research Council. (2001). *Inquiry and the National Science Education Standards*. Washington, D.C.: National Academy Press.

National Research Council. (2011). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academy Press.

National Research Council. (2013). *Monitoring progress toward successful K-12 STEM education: A nation advancing?* Committee on the Evaluation Framework for Successful K-12 STEM Education. Washington, DC: The National Academies Press.

National Research Council. (2014). *Developing Assessments for the Next Generation Science Standards. Committee on Developing Assessments of Science Proficiency in K-12*. Board on Testing and Assessment and Board on Science Education, James W. Pellegrino, Mark R. Wilson, Judith A. Koenig, and Alexandra S. Beatty, Editors. Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies Press.

Nelson, T. H. (2009). Teachers' collaborative inquiry and professional growth: Should we be optimistic? *Science Education, 93*(3), 548-580.

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

Noam, G., Dahlgren, C., Larson, J., Dorph, R., Goldstein, D., & Sheldon, J. (2010). *Are quality science learning opportunities typical of afterschool settings?* Paper presented at the American Educational Research Association, Denver, CO.

Osborne, J. (2012). The role of argument: Learning how to learn in school science. In *Second international handbook of science education* (pp. 933-949). Springer Netherlands.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge, UK: Cambridge University Press.

Pacey, A. (1983). *The culture of technology.* Cambridge, MA: MIT Press.

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

Patton, J., Polloway, E., & Cronin, M. (1990). *A survey of special education teachers relative to science for the handicapped*. Unpublished manuscript.

Penuel, W. R., & Gallagher, L. P. (2009). Preparing teachers to design instruction for deep understanding in middle school earth science. *Journal of the Learning Sciences*, 18(4), 461-508.

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

Citations

Perkins, D. (1993). Person-plus: A distributed view of thinking and learning. In G. Salomon & J. S. Brown (Eds.), *Distributed cognitions: Psychological and educational considerations* (pp. 88–110). Cambridge, UK: Cambridge University Press.

Pfeffer, C. A. (2012). Normative resistance and inventive pragmatism: Negotiating structure and agency in transgender families. *Gender & Society, 26*, 574-602.

Quinn, H., Lee, O., & Valdes, G. (2012). *Language demands and opportunities in relation to Next Generation Science Standards for English language learners: What teachers need to know*. Commissioned Papers on Language and Literacy Issues in the Common Core State Standards and Next Generation Science Standards.

Rand, A. (1938/2009). *Anthem*. Rockford, ENG: BN Publishers

Rand, A. (1964). Introduction. *In The Virtue of Selfishness*, pp. vii–ix New York: New American Library.

Rand, A. (1967). *Capitalism: The Unknown Ideal*. New York, NY: Signet

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

Richmond, G., & Manokore, V. (2011). Identifying elements critical for functional and sustainable professional learning communities. *Science Education, 95*(3), 543-570.

Rosenblatt, L. M. (1956). The acid test for literature teaching. *English Journal*, 66-74.

Roth, K. J. (2009). *Using video studies to transform science teaching and development program*. In Janík, T., & Seidel, T. (eds.) The power of video studies in investigating teaching and learning in the classroom. Waxmann Verlag.

Royal, Camika, (2013). "Please stop using the phrase achievement gap." *Good*. Retrieved from: http://magazine.good.is/articles/please-stop-using-the-phrase-achievement-gap.

Rudolph, J. L. (2002). *Scientists in the classroom : The cold war reconstruction of American science education* (1st ed.). New York: Palgave.

Schneider, R. M., Krajcik, J. and Blumenfeld, P. (2005), Enacting reform-based science materials: The range of teacher enactments in reform classrooms*. Journal of Research in Science Teaching*, *42*, 283–312.

Schweingruber, H. A., Duschl, R. A., & Shouse, A. W. (Eds.). (2007). *Taking Science to School:: Learning and Teaching Science in Grades K-8*. National Academies Press.

Schweingruber, H., Keller, T., & Quinn, H. (Eds.). (2012). *A Framework for K-12 Science Education:: Practices, Crosscutting Concepts, and Core Ideas*. National Academies Press.

Settlage, J. & Johnston, A. (2014). The Crossroads Model. *Educational Leadership*, *71* (8), 67–70.

Shymansky, J. A., Wang, T., Annetta, L. A., Yore, L. D., & Everett, S. A. (2012). How much professional development is needed to effect positive gains in K-6 student achievement on high stakes science tests?. *International Journal of Science and Mathematics Education*, *10*(1), 1-19.

Simmons, P. E., Emory, A., Carter, T., Coker, T., Finnegan, B., Crockett, D., . . . Labuda, K. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching*, *36*(8), 930-954.

Sizer, T. (1999). That elusive "curriculum." *Peabody Journal of Education*, *74*(1), pp. 161 – 165.

Smetana, L.K., Coleman, E.R., Ryan, A., & Tocci, C. (2013). Teaching, learning and leading with schools and communities: preparing sophisticated and resilient elementary STEM educators. *Teacher Education and Practice, 26*(2), 300-320. Author's version available at http://ecommons.luc.edu/education_facpubs/25

Solano-Flores, G., & Nelson-Barber, S. (2001). On the cultural validity of science assessments. *Journal of Research in Science Teaching, 38*(5), 553-573.

Star, S. L., & Bowker, G. C. (2007). Enacting silence: Residual categories as a challenge for ethics, information systems, and communication. *Ethics and Information Technology*, *9*, 273–280.

Stoddart, T., Pinal, A., Latzke, M., & Canaday, D. (2002). Integrating inquiry science and language development for English language learners. *Journal of Research in Science Teaching, 39*(8), 664-`687.

Tabachnick, B. & Zeichner, K. (1999). Idea and action: Action research and the development of conceptual change teaching of science. *Science Education, 83*(3), 309–322.

Tan, E. (2014). Human capital theory: A holistic criticism. *Review of Educational Research*, *84*, 411-445.

Taymans, J., Tindle, K., Freund, M., Ortiz, D., & Harris, L. (2012). Opening the black box influential elements of an effective urban professional development school. *Urban Education, 47*(1), 224-249.

Tenner, E. (1996). Why things bite back: Technology and the revenge of unintended consequences. New York: First Vintage Books Edition.

Terrell, N. (2007). STEM occupations: High-tech jobs for a high-tech economy. *Occupational Outlook Quarterly*, *51*(1), 26-33.

Thompson, J.J. & Hagenah, S. (April, 2014). *Rigor and responsiveness in classroom activity*. Paper presented at the annual meeting of the American Educational Research Association, Philadelphia, PA.

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

van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching*, *38*(2), 137-158. U

Van Duzor, A. (2011). Capitalizing on teacher expertise: Motivations for contemplating transfer from professional development to the classroom. *Journal of Science Education and Technology*, 20(4), 363-374.

vanEs, E.A., & Sherin, M. G. (2009). The influence of video clubs on teachers' thinking and practice. *Journal of Mathematics Teacher Education*, 13(2), 155–176.

Volti, R. (2010). *Society and technological change*. New York, NY: Worth Publishers.

Waight, N. (2013). Technology knowledge: High school science teachers' conceptions of the nature of technology. *International Journal of Science and Mathematics Education.*

Waight, N., & Abd-El-Khalick, F. (2012). Nature of technology: Implications for design, development, and enactment of technological tools in school science classrooms. *International Journal of Science Education, 34*, 2875-2905.

Waight, N., Chiu, M. M.; Whitford, M. (2014). Factors that influence science teachers' selection and usage of technologies in high school science classrooms. *Journal of Science Education and Technology*.

Washburn, E., & Cavagnetto, A. (2013). Using argument as a tool for integrating science and literacy. *The Reading Teacher*, *67*(2), 127–136.

Wenger, E. (1999). *Communities of practice: Learning, meaning and identity*. New York: Cambridge University Press.

Westbrook, R. B. (1991). *John Dewey and American democracy*. Ithaca, NY: Cornell University Press.

Wetherell, M. (1998). Positioning and interpretative repertoires: Conversation analysis and post- structuralism in dialogue. *Discourse & Society*, *9* (3), 387-412.

Wilde, O. (1893/2003). *The Disciple*. In Oscar Wilde: Complete short fiction, Small, I. (Ed.), p. 246. New York, NY: Penguin Classics.

Wilson, D.S. (2011). *The neighborhood project: Using evolution to improve my city one block at a time.* New York: Little Brown and Company.

Wilson, D.S., Ostrum, E., Cox, M. E. (2013). Generalizing the core design principles for the efficacy of groups. Journal *of Economic Behavior & Organization*, *90*, S21-S32.

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. Itascu, IL: F.E. Peacock Publishers.

Windschitl, M., Thompson, J., Braaten, M., & Stroupe, D. (2012). Proposing a core set of instructional practices and tools for teachers of science. *Science Education, 96*(5), 878–903.

Wortham, S. E. F., Murillo Jr., E. G., & Hamann, E. T. (Eds.). (2002). *Education in the new Latino diaspora: Policy and the politics of identity* (Vol. 2). Greenwood Publishing Group.

Wynne, B. (1992). Misunderstood misunderstanding: Social identities and public uptake of science. *Public Understanding of Science*, *1*(3).

Wysession, M.E. (2013). The Next Generation Science Standards and the Earth and Space Sciences. *Science Scope*, *36* (8), 13-19.

Yamagata-Lynch, L. C., & Haudenschild, M. (2006). Using activity theory to identify contradictions and tensions in teacher professional development. *Presentation at the 2006 Annual Meeting of the American Educational Research Association (AERA). April 11, San Francisco, CA.*

Yep, L (1975). *Dragon Wings*. Harper & Row, CA.

Zeichner, K. (2006). Reflections of a university-based teacher educator on the future of college-and university-based teacher education. *Journal of Teacher Education, 57*, 326-340.

Zembal-Saul, C. L., McNeill, K. L., & Hershberger, K. (2012). *What's your evidence?: Engaging K-5 children in constructing explanations in science*. Boston, MA: Pearson.