Science Education at the Crossroads

April 25 – 26
San Antonio, Texas

2017 Conference Proceedings

Welcome!

We are thrilled to welcome you deep in the heart of Texas, where as the song goes, the stars at night are big and bright. This city emerged from a time of uncertainty in history, when Texas was not yet part of the United States, and was attempting to secede from Mexico. In a sense, the war of Texas independence (1835-1836) represents a bridge between the eras of American history. Pre-war, America was attempting to build a country after years of rebellion. Post-war, America expanded quickly, resulting in decisions that would lead to the Civil War. San Antonio also cultivated a cultural bridge between worlds, providing a hub of activity between Mexican citizens, Indigenous people of northern Mexico, American settlers, and immigrant families shepherded to the expanding United States' territories. Noted landscape architect Frederick Law Olmsted noted in 1859 that San Antonio was a "jumble of races, costumes, languages, and buildings."

Though the analogy is a stretch, we, as teacher educators, find ourselves standing on a bridge across ideas and eras. We are living through three important and palpable shifts in science education:

1) From emphasizing teacher knowledge to teacher practice(s)
2) Reframing teaching as the facilitation of student participation in practices rather than information delivery
3) Attempting to understand our role as teacher educators, researchers, and activists for the teaching profession (and K-12 students).

These shifts are not separate; rather, they are woven into national conversations about the purpose of schools, teaching, and education. We stand on a bridge between the shifts and these conversations, trying to find footing as we articulate why we matter in the lives of teachers and students.

In our hearts, we know that our work as teacher educators does matter, and it is our collective focus on ambitious instruction, teacher learning, equity, and science practices brings us together for the 2017 edition of Crossroads. Note that we are breaking mold of Crossroads this year, as John and Adam have kindly offered this space to us for a specific conversation about teacher education. This reimagined and negotiated Crossroads is symbolic as we discuss concepts such as ambitious instruction that prompt many questions, many unknowns, and many paths to pursue. It is also appropriate that our speaker, Jaime González, bridges worlds between science and policy, schools and businesses, environmental activism and a sprawling urban space.

In the pages that follow, you have an opportunity to peer around and over the bridge at your feet. Perhaps you want to walk towards conversations about policy, or about moment-to-moment talk moves in methods courses. Perhaps you sense a rising tide of disdain for the teaching profession, and you want to find ways to argue back. The beauty of Crossroads is that you build a bridge of your own interests, and then test its strength through conversations with colleagues. How you construct your bridge as a teacher educator is up to you, but this space allows you access to building materials not available in other spaces (such as other San Antonio-based conferences). We encourage you to stand tall and look around. You never know what you might see.

David Stroupe and Hosun Kang (hosts)
Adam Johnston and John Settlage (organizers)

References

Olmsted, F. L. (1859). *A journey through Texas: Or a saddle-trip on the southwestern frontier*. Lincoln, NE: University of Nebraska Press.

PROGRAM SCHEDULE

Tuesday, April 25th

2:00 – 7:00 pm	Arrivals	**St. Anthony Hotel**, 300 E Travis St, San Antonio, TX
7:00 – 8:00 pm	We Begin	**Reception & Welcome** *David Stroupe & Hosun Kang*
8:00 – 8:30 pm	Incubator 0	**La Primera Tortilla –** *Nate Wood, Adam Johnston, & John Settlage*

Wednesday, April 26th

8:45 – 9:00 am	Welcome	*Re-Welcome & Fresh Introductions*	
9:00 – 10:15 am	Incubator 1	Ron Gray & Andy Gilbert	MORRISON
		Michael Giamellaro & Francis Broadway	NAYLOR
10:15 – 10:45 am	Break		
10:45 am – noon	Incubator 2	Danielle Ross & Rosemary Russ	MORRISON
		Kirsten Mawyer & David Stroupe	NAYLOR
noon – 1:29 pm	Lunch		
1:30 – 2:45 pm	Incubator 3	Doug Larkin & Eve Manz	MORRISON
		Ed Lyon & Mark Windschitl	NAYLOR
2:45 – 3:15 pm	Break		
3:15 – 5:15 pm	Incubator 5	Hosun Kang & Marti Canipe & DeeDee Wright	MORRISON
		Heather Johnson & Christine Bae	NAYLOR
5:30 – 7:29 pm	Free Choice	Continue conversing, stretch your legs, find some dinner …	
8:00 – 8:30 pm	Treats	Dessert Reception	LIBRARY
8:30 – 9:30 pm	GUEST PRESENTER	***Jaime González*** "Teaching Homebase in a Global Age: Tales from the Katy Prairie"	

Special thanks to Rebakah Alvarez for being such a wonderfully accommodating hostess!

The Facilitators

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 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 and that time allocation tracks this very precise schedule and sequence:

- 10 minutes for the presenter to describe the Vexation/Venture (without interruption)
- 5minutes 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.

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. Their agreed upon compensation is a flow of refreshing beverages. Two UConn graduate students, Shelby Little & Kevin Agnello, are present to document the Faciltation.

Incubator Etiquette

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

Citing Your Paper

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

Your name. (2017). Title of your talk. Paper presented at Science Education at the Crossroads, San Antonio, TX, April 25-26. Available online at www.sciedxroads.org/proceedings2017.html.

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

Your name. (2017). Title of your talk. In D. Stroupe & H. Kang (Eds.), Proceedings of the Science Education at the Crossroads Conference (pp. xx-xy). San Antonio, TX. Available online at www.sciedxroads.org/proceedings2017.html.

Using an Improvement Science Paradigm to Support Science Teacher Preparation

Christine Lee Bae, *Virginia Commonwealth University*

VEXATION

1. **Enormity of shifts envisioned in the new science standards and implications and challenges for science teacher preparation (including both faculty and students):** *How do we simultaneously support science methods faculty AND their teacher preparation candidates in developing a deep understanding of science reforms and translating these understandings to practice?*

Working closely with science educators and preservice teachers in the context of methods courses in California, an exciting but also challenging shift that we are facing is how to adopt and implement the new Framework for K12 Science Education (NRC, 2012) as articulated in the *Next Generation Science Standards* (NGSS Lead States, 2013). California being one of the early NGSS adopting states, we have experienced a great momentum behind the considerable shifts required by the new science standards, such as a wave of professional development opportunities (funded at the district, state, and federal levels) and emerging curricular materials from close partners such as WestEd and other university-based teams in the Bay Area. However, the spotlight and reform efforts in California have focused primarily (and understandably) on the inservice sector. *Teacher preparation in higher education has a significant role in the implementation of the new science reform documents and with it, its own unique challenges*. Additionally, although still in its nascent stages, implementation of the new science reform is hindered by considerable capacity issues within and across stakeholder organizations. A review of literature across multiple disciplines yielded a number of impediments to achieving instructional goals of past and current science reform efforts (Ball & Forenze, 2013; Bryk et al, 2015; Penuel et al., 2010). Most significant is that there is little research on how aspiring teachers develop the knowledge and skills needed to make the conceptual and instructional shifts from their own science education experience (Ball, 2015; Lederman, 1999; NAP, 2010). Additionally, science methods instructors are simultaneously developing their own understanding of new science education reforms and preparing their preservice teachers in understanding reform-based science pedagogy that represent a significant departure from traditional approaches to science education (Bybee, 2014).

One challenge we identified through our work in the context of a NSF DRK12 project is that supporting future science teachers (preservice candidates) is integrally tied to, and largely contingent on, support **the university faculty** who are preparing these preservice teachers. While our project initially focused on creating tools to support preservice teachers' developing understanding of NGSS shifts, it became clear to us early on (during the first year of the project), that the science methods faculty also needed support and resources to understand the new standards. One challenge specific to our setting, that is also shared in many other institutions is that there is commonly only one science methods faculty member in their department (or perhaps two- elementary and secondary), and they are typically working in isolation.

2. **Heavy reliance on science curriculum in secondary science teaching:** *How do we support faculty and* students' critical evaluation and adaptation of existing science curriculum *as they tackle new science standards in teacher preparation contexts?*

Preservice and inservice sectors are clamoring for NGSS-aligned curriculum to guide their understanding and shifts towards new science standards. It has been argued that the success of new science standards rests heavily on curriculum materials aligned with the goals of new reform (Krajcik, McNeill, & Reiser, 2007). In many ways, the success of new science standards rests heavily on curriculum materials aligned with the goals of new reform (Krajcik, McNeill, & Reiser, 2007). What we have found is that when learning about theories, pedagogy, and standards, both inservice and preservice teachers repeatedly ask "What does this look like in the classroom? Is there an example 'NGSS' lesson?" While curricular materials provide the raw materials for instruction, we know both from research and our work that there is diverse enactments of curriculum by teachers who select and adapt materials based on their beliefs about teaching, and their understanding of the unique needs of their students (Ball & Cohen, 1996; Fogleman, McNeill, & Krajcik, 2011).

Using an Improvement Science Paradigm to Support Science Teacher Preparation

Christine Lee Bae, *Virginia Commonwealth University*

VENTURE

Improvement Science (IS) as a Framework for Tool Research and Development: *What does IS research look like in education*? We partnered with Stanford's Carnegie Foundation for the Advancement of Teaching to learn about and implement IS methods. A major part of this effort was the development of a Networked Improvement Community (NIC) consisting of science methods faculty from 6 other university campuses. The theoretical framework of *IS* (Berwick, 2008; Bryk, Gomez, & Grunow, 2011) embraces variation as a crucial source of information and which may be incorporated in subsequent versions of the intervention under development. Rather than implementing an innovation fast and wide and then fixing the problems later, IS accelerates learning by deploying small rapid and iterative *Plan, Do, Study, Act* (PDSA) cycles at low cost to make changes quickly and incrementally. Of note, while IS methodology is well established in other industries and slowly emerging as a framework for continuous improvement in K-12. While I celebrated many successes, such as mutually beneficial debriefs and problem-solving regarding the tools between methods faculty and the research team via monthly teleconferences, and data collection from the science methods courses to begin building a body of evidence for IS as a framework for continuous learning, we are still unclear of **exact protocols and processes to develop and maintain the NIC**, particularly as the grant funding period is coming to a close. The details of executing IS in education reform, particularly at the university level, are still largely unknown; "there exists no genre of writings for reporting improvement work in education" (LeMahieu, Edwards, & Gomez, 2016, p. 448). At Crossroads, I would like to discuss, with other educators, the emerging theory, evidence, and use of IS in education. **My questions for Crossroad scholars are:**

- What supports and resources are available and/or needed to support **science methods faculty** develop the knowledge and skills needed to make reform-based conceptual and instructional shifts?
- How do we **build a network of science methods faculty across** institutions to facilitate ongoing discussion and sharing of resources towards making systematic improvements in teacher preparation, particularly given the advent of NGSS?
- What does learning of science teaching look like **as both faculty and preservice teachers grapple with new standards** in the context of a science methods course? How can we better understand this process and to support deep processing and ownership of best practices (for both instructors and students)?

Developing tools to examine science lessons: *How can our tools be used across different science methods courses?* We seek to share our experiences and gain feedback regarding our tools aimed at supporting science methods instructors and preservice teachers' emerging understanding of the vision for three dimensional, disciplinarily-integrated science education. The "Toolkit" contains a set of rubrics and processes to be used in science methods classes to develop science method faculty's and preservice teachers' understanding of the NGSS science and engineering practices. We identified that a poster-size 3-Dimensional Mapping tool was particularly effective for helping preservice teachers 1- make connections between different dimensions of NGSS with explicit examples from existing lessons, 2- make connections between NGSS and pre-existing methods course goals (e.g., assessment, learning goals, disciplinary content), and 3- have detailed conversations about how to improve lessons to align with standards. An important goal of the larger project was that the tools and associated processes can be used reliability and effectively, while remaining flexible enough to adapt the unique goals, credentialing requirements, routines and other components of different science methods courses across universities. At Crossroads, I would like to present this 3D map, share examples (through pictures and descriptions) of the various ways it was used in our science methods courses, and receive feedback from Crossroad colleagues regarding the strengths and weaknesses of such graphic-organizers for facilitating preservice teachers' understanding and application of standards to curriculum materials. Given the complexity of designing and enacting standards-based curriculum lessons, **my questions for Crossroad scholars are**:

- How do we support preservice teachers in ***critically*** examining, evaluating, and adapting existing science lessons?
- How can we integrate teaching new standards with existing science methods course goals?

A Nightmare Called Teaching K-12 Science: So What?

Francis S. Broadway, *The University of Akron*

VEXATION

A nightmare cometh, but is not here as the dreaming, the thinking, and the facts on the ground have made the nightmare a non-issue, but nightmares, even when placed under the bed (as I look less often under the bed than I do in the closet), never go away. The nightmare Is to teach in a K-12 school.

Returning to teaching in a K-12 school became the option when a reality struck me that my university job more likely would disappear. If I was to leave my current position, then, I would need to teach in a K-12 setting, most likely high school chemistry although physical science or middle school earth science would do. So, the brain asked, "So what would you do on the first day?"; "How would you go about doing all the things you have been telling teachers to do in your K-12 classroom?" The heart asked – hence the nightmare – "Are you afraid?"

It has been almost 20 years since I walked out of my middle school seventh and eighth grade science and mathematics classroom after 19 years of high school physical science, chemistry, physics (one year), middle school earth science and seventh and eighth grade science (biology and earth science) and mathematics (7th grade mathematics and pre-algebra) teaching into a Doctor of Philosophy in Elementary Education at the University of South Carolina to focus on science education as a Holmes Scholar. In those 20 years, to date, I have not taught a secondary or middle school science methods course, but I have taught numerous elementary and early childhood content methods courses, early childhood and middle level literacy (reading and writing) courses, curriculum theory courses, et cetera. I have facilitated and "run" grant supported professional development programs for early childhood, elementary, middle-level, secondary, undergraduate student…. You get the picture. I have continued to be successful at school, by remaining in school. You get the picture. I would do anything, almost anything, not to go back to the K-12 classroom as a teacher as that is the only thing, I think, the State of Ohio would license me to be. So, what are you afraid of?

Although I fear I do not know what is a K-12 classroom these days, I do not know how to prepare to be a K-12 classroom teacher. I would not be the K-12 teacher of whom I speak and want to create in the university classes that I teach. I fear that in the classroom I would be the teacher who walked out the classroom 20 years ago which means, I fear I have not grown in experience and wisdom, I just grew older.

However, what does a high school class look like, today? If I model my description based on a school district with which I have done extensive work, then I know there are standards, a pacing guide (often called the racing guide), middle of the term and end of the year examinations, and one district-wide adopted textbook. I know there are homework and grades to give and to post, and parents to inform. I know I will be evaluated not by how I teach, but how students perform on a test that has no established validity and determinable reliability and is reported to measure science learning and mastery. I will be the sage not only for the students who are unknown and assigned to me, but also for the teachers who I need to be critical friends. The teachers are caring and knowledgeable. I know the location from where the schools gather its flock, but do not know the place from which these students come. If the nightmare is truly a nightmare, then I see myself knowing, but standing naked.

In the nightmare, I saw my only option of teaching was in a public school – either a "Urban - High Student Poverty & Average Student Population [district or a] Urban - Very High Student Poverty & Very Large Student Population" (ODE, 2014) district whereas my 19 years of K-12 teaching were in three independent schools, before the standards movement, where I could choose my textbooks, and elitism was a state of being not to be questioned. Although I most often taught the "regular" students, I seldom taught the AP or gifted students as a badge of courage, but I did not teach "urban" students. I do not apologize from my choice of where to teach.

VENTURE

1. How do I (re)prepare to be a K-12 science teacher?
2. So what if my vexation is teaching in a K-12 setting a nightmare and I will not (never) teach in a K-12 setting?

Hidden in the questions: How do I prepare to be a K-12 science teacher? What does K-12 science teaching look like? What actions define the K-12 science teacher? Secondarily, how does the nightmare inform my practice as a university instructor and researcher? or why is all of this – knowledge – of worth?

A Nightmare Called Teaching K-12 Science: So What?

Francis S. Broadway, *The University of Akron*

The most simplistic venture would be (1) to teach one of the science methods courses; (2) to do extensive visits; to co-teach (Roth & Tobin, 2005) or to research in naturalistic context-specific setting; (3) to engage in the dialectic (Greene, 1988) with teachers and students; and so on…, but I reject these because I want not to be the emperor in his new clothes. I go back to the image of me in my nightmares where I stand naked in the Schrödinger and Heisenberg electron cloud-like mass of not-learning, withholding their assent to learn (Kohl, 1991), students yelling, "But he isn't wearing anything at all!" These aforementioned possibilities are what one does rather than what one is (Butler, 1993). Thus, the nightmare of teaching K-12 science is the nightmare of self who is the self that I was once – the self who taught before there were standards and what was in the textbook including those textbooks that were dedicated to a quantitative approach to science learning and instruction through laboratory-centered and process of inquiry investigations (Brock, Paulsen, & Weisbruch, 1967; Weibruch, Donovan, & Hingar, 1968) or the high school version of the freshman textbook or the individual who crafted, created, wrote and graded assessments and evaluation which all those who were successful doing school continue to do be awarded the highest grades, but was able to brag that more than one student reported that they learned little science, but a great deal about life. The fear is that I do not know; I do not believe.

So what? might be answered by stating the aim of school is the replication, assimilation, and socialization of the self into an obedient, compliant and complacent being. I am seeking to explain why I need to be afraid of the nightmare called teaching K-12 when I have convinced myself (before your input) that I have good reason to know that my university job will not disappear before I retire. (So the whole discussion is useless and meaningless, but I cry otherwise.) Does teaching require that the person that I show to myself is indeed myself or do I just ignore that self – be obedient, compliant and complacent. I ask If ignoring myself or questioning myself, then am I allowed to be the capitalist, the entrepreneur? Specifically, must I say, just learn the science in the textbooks (and on the test) and use methods to make the content of the text digestible (to whom)? Why teach? Furthermore, the nightmare is important because after 20 years of studying, writing, presenting, arguing, etc. I have not change and thus the energy that I and the field of science education has expended will not change the way (1) students learn science, (2) the teachers teach science, (3) schools school (4) we, students, teachers, schools, do our, the world’s, work and (5) we, in our place (Whitlock), measure worth. Maybe my fear, the nightmare, is I am moving in a world where normal is a “feeling of despair and hopelessness that pervades people who feel with justification that they have no real say in shaping or determining their own destinies” (Reid, 1972, p. 5) – alienation.

In the vain of Jackson (1966; 1968) and Eisner (1979), the nightmare called teaching K-12 science exposed my explicit curriculum (Sizer, 1983). The nightmare unearthed the hidden curriculum too. To be more specific, my venture, and the primary question on which I have been reflecting and I need you to address is What do I see in a university classroom is required to be in a K12 classroom? In other words, (1) What pedagogical characteristics must be present in a university, subject-specific or not, classroom that must be present in a model K12 classroom if the science learning is to be educative? (2) How do you describe the university classroom as a similar and congruent place called the K12 science classroom whereby place encourages and reinforces traits and behaviors socially, culturally and politically within a location and person-shapes?

So I see myself beginning my first day in the K12 science classroom as removing with the neoliberal shackles of the white(-faced) savior teacher, “this teacher was so great he changed these lousy kids” (Horan, 2015) my magical teacher persona, “this teacher was able to bring out what was already wonderful about his students” because school and teaching science are preformative (Butler, 1990). I can do school. Since school science is connected to life as curriculum and pedagogy, I can teach differently and since not-learning is learning (Kohl, 1983), learning school science content and learning not-learning science content is in the direction of learning who I am. No matter how much this venture turns about on itself to be about “learning who I am”, I will end this with the moral of the story: Who cares what one learns in a high school science classroom as long as one learns who one is by “finding teaching strategies that make this, the problematized content more palatable to students” (Luhmann, 1999).

Finding the Goldilocks Zone: Supporting Preservice Elementary Teachers in Developing an Ambitious and Approachable Vision of Themselves as Teachers of Science

Marti Canipe, *Northern Arizona University*

VEXATION

In astronomy there is an idea known as the Goldilocks Zone – that region in a star's planetary system where the planet is at just the right distance from its star so that liquid water can exist. In our solar system, Earth is in that Goldilocks Zone not too close and not too far – it's "just right." I am curious about the Goldilocks Zone for preparing preservice elementary teachers to teach science. Where is that spot that is "just right" for them – where their vision of teaching science is ambitious and yet still within reach as novice teachers.

During the last five years, I have worked with many preservice elementary teachers as their science methods instructor. I begin each semester with a science biography survey in which I ask students to share their own experiences with science as a student as well as their feelings about teaching elementary science. In these biographies, I noticed that I got a range of affinities for science; everything from "I love science and I can't wait to teach science" to "I don't science" with more of the responses falling towards the "I don't science" end of the spectrum. As an instructor, these vastly different starting points led me to consider what I can do over the course of a semester to move students towards an ambitious, but approachable vision of themselves as a science teacher. This central challenge of practice as an elementary science teacher educator also became the focus of my research which centers on elementary teachers' identities as teachers of science.

Teachers' identities impact how they understands what it means to be a teacher (Sachs, 2005), therefore understanding teachers' identities as teachers of science and how these identities develop is particularly interesting for me as both a teacher educator and researcher. Secondary science teachers often have identities which are strongly tied to science as a discipline (Helms, 1998). In contrast, elementary teachers are generalists, expected to teach students across many disciplines and as such, often do not identify with a particular subject area (Davis, Petish, & Smithey, 2006). In making an argument for using identity development as a lens for teacher preparation, Luehmann (2007) noted several challenges facing prospective science teachers. These challenges included a disconnect between what prospective teachers learned about teaching science in their coursework and their own experiences as learners of science and what they might see in traditional school settings (Luehmann, 2007). This challenge may be especially acute for preservice elementary teachers since science is taught less in elementary schools than other subjects and it is often presented as a collection of vocabulary and facts rather than in ways that engage students in the practices of science (Banilower et al., 2013).

I have explored preservice elementary teachers' identities as teachers of science and teachers of students. I considered this through two lenses. First, I explored the stories (Sfard & Prusak, 2005) that were told by and about preservice teachers as teachers of science and students. Second, I examined how aspects of these stories or others were enacted when preservice teachers taught science lessons in their student teaching placement classrooms. In this research, I explored preservice teachers' identities at that moment as student teachers (actual identities) as well as who they expected to be in the future (designated identities). This gap between actual and designated identities has the potential to be bridged by learning (Sfard & Prusak, 2005).

The findings from this study suggested that the size of the gap between actual and designated identities varies among preservice teachers, despite being at the same point in their teacher preparation program. In the three cases I examined, I found three different sizes of gaps. In one case, there was little to no gap since the preservice teacher, Valentina did not tell a story of her future self that was different from whom she was at the present time. In Emmy's case, her actual and designated identities were separated by a large gap. In fact, there were aspects of who she thought she would be in the future that Emmy described as things she "couldn't do right now, maybe in five years." In the final case, the gap was smaller and Cecelia, the preservice teacher, experimented with ideas that she described as being aspects of the teacher she hoped to become and reflected on how well she was able to meet this vision of her future self. The size of the gap may therefore support or constrain learning opportunities for preservice elementary teachers. In the cases of Valentina and Emmy, their opportunities to learn may have been limited because the gap between their actual and designated identities was almost non-existent or was so large that it seemed out of reach. In contrast, the case of Cecelia showed that when the size of the gap is optimal it afforded her learning opportunities as she tried out aspects of her designated identity.

Finding the Goldilocks Zone: Supporting Preservice Elementary Teachers in Developing an Ambitious and Approachable Vision of Themselves as Teachers of Science

Marti Canipe, *Northern Arizona University*

My vexation lies at the intersection of my practice as an elementary science teacher educator and my research on elementary teachers' identities as teachers of science. At its core, my vexation is a goldilocks problem – how do I support preservice teachers in developing an identity as a novice teacher of science that is "just right" for where they are as novice teachers and that will support their continued learning and development into expert teachers of science? In considering my goals as an elementary science teacher educator and researcher, this vexation expands to include the following questions:

- How do preservice elementary teachers actual and designated identities as teachers of science develop over the course of their teacher preparation program?
- How do I support preservice elementary teachers' development of an identity as an ambitious (Windschitl, Thompson, Braaten, & Stroupe, 2012) teacher of science that is accessible to novice elementary teachers while at the same time offers opportunities for learning?
- What is the role of teacher educators as one voice among many in developing an ambitious and approachable teacher of science identity?

VENTURE

I see my venture as an opportunity to bridge research and practice. As a researcher, I want to understand the stories that are told by and about preservice elementary teachers as teachers of science, how these stories interact, and which stories are significant (Sfard & Prusak, 2005) for their identities. As an elementary science teacher educator, I want my students to see themselves as teachers of science who love science (or at least like it) and want to engage their students in learning about science. I want my research and teaching to work synergistically; so that they are not independent of each other, but rather "talk" to each other.

While I know that the preservice teachers with whom I work are headed towards formal educational settings, I have been thinking about using informal education settings as part of my science methods course. I see several potential advantages to informal settings for science teaching. First, informal settings have a focus on learning being interesting rather than learning as preparation for a test. Perhaps this focus, which is different from what is emphasized in so many classrooms, would allow preservice teachers to think about engaging students in doing science and talking about their ideas rather than emphasizing the acquisition of vocabulary and facts. Second, some research (Katz et al., 2011; Katz, McGinnis, Riedinger, Marbach-Ad, & Dai, 2013) supports the idea that informal science experiences support the development of preservice elementary teachers identities as teachers of science. Finally, informal educational spaces are free from some of the constraints that may limit science teaching experiences for preservice teachers in traditional field placement classrooms.

I am currently in discussions with a local observatory, the local school district's after-school enrichment program, and the local science festival organizing committee about potential collaborations in which my students would have the opportunity to teach science to elementary students in these informal settings. As I engage in these conversations the things I wonder about are:

- What are the potential pitfalls of this endeavor?
- What resistance might I face from within the university teacher preparation program to this endeavor?
- How can I support my students in translating these experiences in informal settings to the formal context in which they will be working?
- Will these experiences support the development of identities as ambitious teachers of science?

We know that there are planets that lie in the Goldilocks Zone in stellar systems beyond our own. These planets have the potential for liquid water, something that is essential for supporting life as we currently know it to exist. I believe that there is also a Goldilocks Zone for preparing elementary teachers as ambitious teachers of science. A place where the gap between their actual and designated identities as teachers of science is one that is "just right" and as such will support their continued learning about what it means to be an ambitious teacher of science.

Crossing the River

Michael Giamellaro, *Oregon State University*

VEXATION

One of the communities I work with in our region is situated on an Indian reservation of confederated tribes. Although the community is built from three very different cultures, largely displaced from their ancestral homelands, they have built a new culture together and it is tied to the new lands of the reservation and to common needs, ideas, and history. The community has a K-8 school that is run by the regional school district rather than the Tribes or BIA but there is some sense of ownership and much integration into the local community. When students go to high school they are bussed across the river that forms the border of the reservation and to the school in the county seat. Many members of the reservation community feel like the experience of going to this other community for schooling, shopping, medical care or other needs represents a huge cultural divide where they must be very conscious of their identity, minority status, and often a significant shift from their ways of knowing, values, etc. When people in the reservation community use the phrase "crossing the river" it is loaded with a deep sense of cultural, historical, familial, and personal separation. They are being asked to be someone else as they make this geographic move and for many this is a daily process.

While I cannot equate the experience of my preservice Master's of Teaching (MAT) students with the complex and troubling socio-cultural history of the American Indian experience, I often find myself coming back to the phrase of "crossing the river" when I consider my students' experience of moving back and forth between the ivory tower and the public schoolhouse. In our coursework we focus on theory and High-Leverage Practices (HLPs) of Ambitious Science Teaching (e.g. ambitiousscienceteaching.org). We discuss what the research shows is our current understanding of most effective teaching practices and how to meet individual needs with differentiated instruction. We examine videos of master and novice teachers, read case studies, and overall paint a picture of what education can look like when pedagogical skill is matched with the idealism and positive outlooks that brought most of these students to teaching in the first place. Within the first few weeks of their teaching placements many, if not most of my students experience a deflation of that idealism and report teacher-centered classrooms, day after day of reading from textbooks, punitive assessments, fixed mindsets, and many of the other ills my colleagues and I "preach" against. In other words, my students can experience an existential crisis when they "cross the river" into the cultures of the schools they are placed in.

Of course, this is a perennial and multi-layered problem in teacher education and the scope is too large to address at Crossroads. My vexation is more focused on the HLPs related to classroom discourse as this (1) lies at the heart of the sociocultural view of learning our program is built on, (2) lights up the eyes of my students when they see it in action, (3) seems to be one of the harder practices to shift towards, and (4) is rarely seen or practiced during teaching placements. Giving students the reins during discussion changes the locus of control in the classroom, requires an awkward transition and a comfort with silence, and generates the likelihood that learning may not always proceed as planned. The outcomes and feedback are rarely great following first attempts at discourse moves and so even otherwise masterful teachers may try and abandon the ideas. It is not surprising then that Cooperating Teachers (CTs, mentor teachers) are reluctant to adopt, support, model, or provide the time and space for these teaching moves.

After my students adopt the belief that student discourse is powerful and needed they must then "cross the river" where they must simultaneously maintain their identity as an *ambitious science teacher* and develop an identity within a community of practice that they want to become a part of. If the culture of the school does not support the value of discourse learned in the MAT program, my students are left to float between two worlds where they cannot do what they value or value what they end up doing. **My vexation is that when TCs "cross the river" to their placement environments, those environments are often not supportive of discourse moves and this creates an environment where TCs cannot see it or practice it effectively.** Further, TCs as novices are asked to fluidly cross these borders and navigate nuanced cultural differences around classroom discourse before they even understand the broader foundations that both cultures share- an unfair expectation.

It is worth noting that this vexation lives in my role as a practitioner of teacher education and has not really crossed into my scholarship. There is some rich theory with which to explore this idea. Vygotsky's ideas on mediation, Bourdieu's ideas of fields and boundary crossing, Wenger's communities of practice, would all provide robust lenses to examine the problem. To highlight the venture described below, I propose that we examine the problem from the perspective of boundary objects, described in a similar context by Nolen et. al (2011). Tools, artifacts, or reified ideas become boundary objects when they are used to communicate ideas between communities of practice, particularly when the objects help negotiate the relationship between communities of practice, and even if the meaning may shift somewhat from context to context.

VENTURE

Much like the reservation community and the county seat, there will always be a difference in cultures and identities between the ideals of the university classroom and the realities of the K-12 classroom but there is clearly much to be gained by allowing the boundaries between communities to be more permeable. Perhaps boundary objects can facilitate conversations and understanding, leading to a more positive and productive experience for everyone, even if that change is incremental.

I have found that most CTs are generally receptive (in a guarded way) to new ideas that my students bring to their classes. As I consider my ventures in helping CTs bring HLPs into their field placements, there are three that seem to be making some difference: (1) supporting TCs to use HLPs that do not threaten CTs' identities, (2) using artifacts as boundary objects to cross borders between communities of practice, and (3) trying to weaken those boundaries between communities by building professional development relationships with CTs.

Some HLPs can be practiced by my students even though they may not be part of the classroom culture (e.g., *positioning students as competent, teaching toward a big idea*). I have found that it helps when I give assignments that encourage TCs to do so but this can put TCs in the difficult position of operating with a value system outside of their field placement community of practice and can exacerbate the "us vs. them" feeling when used in isolation. It is also does not work well for practicing discourse moves which require much in situ support. We foster a culture of "fail fast, fail forward" but a paralysis seems to overcome many students when asked to turn the discourse over to their own students, particularly when the culture of their placement does not support it. As novices, TCs are not in a good position of communicate what they are striving for.

The use of boundary objects seems to help TCs communicate what they are trying to accomplish and what we are looking for in the program. As experts, the CTs are often adept at seeing beyond the surface details of these tools and helping the TCs enact the desired HLPs, even when they are not part of the classroom culture. Formative assessment has been one such success. Supporting formative assessment in TCs' practice was difficult at first but became much easier when I insisted that they use at least one of Page Keeley's probes as a formative assessment tool. While imperfect, these tools allowed the TC/CT pairs to have rich conversations around formative assessment and blurred the community boundaries for TCs. Some of the CTs have now adopted the tools in their own practice. Another budding but more limited success is the use of Victor Sampson's "Argument-Driven Inquiry" tools. Again, teachers see the value though they fear the time it takes to get students to think and act in different ways than they are used to. We are still struggling with a boundary object to support discourse. The EdTPA rubrics have been useful with TCs but TCs tend to see the rubrics as part of the university culture and not of direct value to their own practices.

I had not identified these efforts as ventures until I thought intentionally about this vexation. A next step is to think more intentionally about the use of boundary objects. For example, (1) Can students be trained to intentionally use boundary objects to quickly foster HLP-friendly learning environments through negotiation with their CTs? (2) As novices with tenuous social positions, is it fair to ask them to do so? (3) How can boundary objects be used to effectively bring effective practices from the field back to the university classroom? I have approached this vexation by working with my students to develop their skills but I recognize that the solution will be a cultural one. How can I bridge the cultures of university and schools so that all participants can participate true to their own identities and calling?

Expecting the most from the least powerful: A case for building ambitious school communities

Andrew Gilbert, *George Mason University*

VEXATION

I am continually haunted by a simple question: *Why do we place so much at the feet of the least powerful and often least prepared…our pre-service teachers?* The evolution of my own ambitious teaching journey has inexorably led me directly to this dilemma. I envision the work of transitioning from being a student to a professional teacher as a reflective journey across a bridge to uncharted territory. Teacher educators have researched excellent ways to scaffold that bridge to guide them into the rich possibilities in their future professional practice. In many cases, teacher educators craft opportunities for pre-service teachers to journey across the bridge into educational terrains to engage as a teacher and then retreat back across the bridge to reflect, deconstruct and consider new possibilities to try on their next journey across the bridge. This is a hallmark of my current teacher education program, where nearly every aspect of coursework is steeped in school experiences through our PDS network. We continually strive to push pre-service teachers through a myriad of ways toward the notion of ambitious teaching that "challenge(s) teacher educators to prepare new teachers to do a kind of teaching that most experienced teachers are not yet doing" (Lampert, Franke, Kazemi, Ghousseini, Turrou, Beasely, Cunard, & Crowe, 2013, p. 226).

Despite the relative success of our elementary education program, I feel as if I owe future teachers more when they enter placement classrooms. Namely, asking future teachers to juggle both developing their science teaching practice as well as creating inquiry-based science classroom cultures seems to be herculean task. On numerous occasions in-service teachers project their fears of science onto pre-service teachers. In these situations cooperating teachers expect pre-service teachers to take more traditional approaches of filling up the children with science facts to avoid content complexity that can emerge through engagement with inquiry. Pre-service teachers are often constrained by rigid pacing guides designed to match state assessments and in some classrooms leave little room even for veteran teachers to maneuver. In these situations pre-service teachers must simultaneously navigate their university expectations regarding inquiry teaching within the constrained context of traditional elementary science classrooms. Can we expect pre-service teachers to develop innovative practice while simultaneously reconstructing the classroom culture regarding science teaching and learning?

I am troubled that I frame their journey to becoming a teacher as crossing a bridge into a land of hopeful possibility, yet often science contexts in schools are desolate terrains. Despite this, I am continually amazed at future teachers' abilities to face their anxieties, engage with science and develop some serious courage as they are often sent into difficult school contexts where even veteran teachers are struggling. I want to articulate these as victories of our approaches in teacher education, but that gnawing ethical question returns. Is there a better way than placing so much on the shoulders of beginners? This question does not suggest we stop challenging our students to develop these ambitious frameworks. They do need powerful opportunities to both develop their pedagogical tools and content understanding as well as the courage to enact them. However, I suggest that the frame of reference must expand well beyond the pre-service teacher.

VENTURE

My teacher educator sensibilities resonate with the excellent work of Windschitl, Thompason and Braatan (2011) who argue for developing tools and habits of mind to set teachers' future trajectories to learn from their practice. Returning to the bridge metaphor, I ask my future teachers to engage with the affective aspects of this journey using wonder and emotion as key entry points to consider meaningful science content and practice. I envision this work as the first steps into 'ambitious science teaching.' However, the development of ambitious practice does not rest solely on the shoulders of teachers and as such I venture to consider the possibilities of building ambitious school communities.

The question to consider is how do we begin constructing an "ambitious school community" in terms of rich inquiry-based science practice? The following venture proposes conceptualizing the goal of engagement with science and STEM related content as the responsibility of the entire school community and begins with the development of trust across school contexts. This approach argues that we must include principals, teachers, parents and children in the work of building the contexts for inquiry. To this end, Smetana, Wenner, Settlage and

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McCoach (2015) demonstrated that trustworthy professional relationships, between teachers and principals, were an essential aspect of successful school science practices and achievement. I would argue that this notion of trust holds for all parties that interact within schools, for instance when children and teachers are engaged in trusting classroom relationships we see more positive classroom atmospheres. The same conditions occur when classroom teachers have a high level of professional trustworthiness for their pre-service teachers. Trust provides the social glue of the classroom and creates the conditions for professional growth in inquiry-based science teaching. In my experience, trust can be increased through interaction that is focused on an understanding for the pressures faced from each participant's viewpoint. In addition, understanding the professional approach to inquiry practice and the complexity that ambitious science teaching entails will also increase trust between pre and in-service teachers. Holding the notion of trust at the core, this venture hopes to build a culture change model for elementary schools and their partner universities.

The question remains how might we construct a culture change model that respects and desires ambitious practice? My goal is to design a research study and a corresponding PDS structure that focus on creating an ambitious school-based culture. I propose the following possibilities:

- Identifying principals that will be open to building ambitious school cultures to take part in a proof of concept study
- Build vertical teaching teams (K-5) including school principals to engage with science and STEM activities designed during summer institutes with the expectation these curricula will be carried out in grade level teams
- Engage in continuous long-term lesson study based on curricular designs
- Impact children's everyday engagement with both open and guided inquiry (after-school science programs run by Mason students, a school-based maker space sponsored by local maker group, family-focused STEM nights and a wonder expo)
- Create well-articulated connections between university preparation programs and school-based partners

These suggestions are designed to work on all aspects of a school community to bring opportunities to engage with inquiry-based science and STEM related notions. I see these ideas as providing far more productive constructs for our future teachers to engage in meaningful practice. For instance, having principals attend the summer institute and be part of the curriculum design activities will send a strong message to teachers about the acceptance and viability of these ideas. Secondly, building vertical teams will help teachers better understand how to scaffold content across important conceptual connections while simultaneously engaging with a broad array of STEM related content. In addition, using lesson study provides the tools and reflection called for in an ambitious teaching framework. The activities described above were the focus of recent a grant proposal, conceptualized by two teacher educators (one in science and one in Math), which was recently funded. The overarching goal is an effort to develop ambitious practice by impacting school-wide cultures. We have partnered with two major school districts and begun the process of identifying possible school sites as well as framing district needs and goals.

Questions for the group to consider as we pursue these ideas:

1) What suggestions might crossroads participants have for moving beyond the individual teacher toward building ambitious communities? Do they see these proposed activities as meeting those goals?
2) What types of data and/or evidence might be valuable to investigate growth in these areas?
3) What might be the political struggles we should consider to provide more academic freedom for schools and teachers to pursue these aspects?

Localized Practice and the Role of Uncertainty in Science Teacher Preparation

Ron Gray, *Northern Arizona University*

VEXATION

In 2014, Eve Manz examined the argumentation practices of elementary classroom communities to examine in situ how these practices develop in comparison to normative views of scientific argumentation. She found that argumentation, as practiced in classrooms, was localized based on the specific contexts in which it was co-developed and implemented. In addition, she showed the importance of uncertainty. It is the uncertainty, she argued, that is an essential driver of the need for practice in the first place. For example, it is the uncertainty in data and interpretive frameworks that drive the need for argumentation, both in science and in the science classroom. This is different from how many scholars had conceptualized science practices in the classroom. A more commonly held idea has been to explicitly teach a generalized structure of the practice, gathered from studies of scientists in action, and apply it in a context that affords little uncertainty. For example, the practice of argumentation can be reduced to the presence or absence of certain components (e.g., claims, warrants, rebuttals) and taught in a highly structured activity (e.g., using clear-cut data). This strategy is in contrast to other scholars (Berland & Hammer, 2012) who instead seek to design experiences that utilize uncertainty to establish a need for such a practice (Manz, 2014). In this way, the science practices are emergent in that they are constructed by the community to solve real problems, such as understanding the next steps in an activity based on data that does not easily lend itself to one answer. Science practices imagined in this way do not easily transfer between contexts as they are localized and contingent in nature (Lave & Wenger, 1991).

For the past six years, I have utilized the literatures in science (Kloser, 2014; Windschitl, Thompson, Braaten & Stroupe, 2012) and mathematics (Kazemi, Franke & Lampert, 2009) education to identify another type of practice, core instructional practices, to frame the work of science teaching for my novice educators. These include core practices such as 'facilitating small and whole group discussions for a purpose', 'eliciting students' initial ideas', and 'facilitating effective openers and closures of lessons'. I have worked with colleagues to integrate these core practices into our program and to identify appropriate teacher education pedagogies to support our students' understanding and ability to implement the practices in their field placements. However, if I take the lessons learned from Manz – localized practices emergent from uncertainty – and apply them to core practices in a teacher education context, it precipitates a number of questions.

First and foremost, how do we establish a need in our novice teachers for the core instructional practices we believe to be essential? This question is relevant to both the university and the practicum classrooms. Most of my students have very limited experience in secondary classrooms which makes the initial practicum observations vitally important to framing their work in the program and beyond. Their professional vision is largely shaped by what Lortie (1975) referred to as the apprenticeship of observation which provides a limited lens from which to look at the work of teaching. The novice teachers rarely observe the true complexities of classroom teaching and thus the need for instructional practices to elicit students' ideas, for example, are not emergent.

Second, what is the role of tools and other supports in helping our teachers understand and engage their students in these instructional practices? By tools I am referring to scaffolds that leverage the resources of individual teachers to design and enact complex instructional practices in a way that might otherwise be out of reach without assistance. The design of tools is complicated. On the one hand, the tools need sufficient detail and direction to scaffold the complex intellectual work of planning for ambitious instruction for the novice teachers. On the other, it needs to be designed in a way to provide the flexibility to implement them in the varying contexts our novice teachers face in the schools. I have attempted to design tools around instructional practices that have turned out to be overly detailed and tools that were too general and thus not useful. I have yet to find the right balance of detail and flexibility.

Third, how do we evaluate our novice teachers' abilities to implement instructional practices in their local context? This is analogous to the dilemma identified by Manz (2014) in the competing strategies of strict definitions of the practice (e.g., presence of claims, warrants, etc.) and allowing for localized practice with standards that are emergent from the classroom community. Not being in an edTPA state, we are specifically challenged by the evaluation of our novice teachers. If we have designed a framework built around instructional

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practices, this should be the backbone of our evaluation process. If our students cannot adequately utilize the instructional practices, we need a way to maintain a standard. Thus, with the idea of localized practice and therefore variability in the ways instructional practices can be enacted across contexts, how do we maintain a standard?

Taken together, then, my vexation is: What role can localized instructional practices and the necessity of uncertainty in establishing a need for practice play in preservice science teacher preparation programs. I believe a discussion around this question is significant for the community of teacher educators attempting to frame their work in similar ways. As a field, we have a growing consensus as to what effective science teaching looks like. We have also done the work to identify potential instructional practices. What we need to develop now are teacher education pedagogies that effectively integrate coursework and fieldwork to provide novice teachers with the experiences to become highly effective first year teachers.

VENTURE

For my venture, I have started by finalizing the framework for our preservice science teacher preparation program and am beginning to more precisely match coursework, assignments, and fieldwork around the framework to increase the coherence of the program. This coherence involves establishing a common language, based on the framework, early in the program to allow for more concise and in-depth discussion about teaching. Finally, it has necessitated a restructuring of the program, especially the methods sequence, to spend more time on a smaller number of things (i.e., instructional practices).

In terms of using uncertainty to establish a need for practices – in this case instructional practices – I have begun utilizing instructional rounds early in the program. Modeled after medical school rounds, we, as a class, observe one period of a teacher's class and debrief with the teacher immediately afterwards. This allows me to help direct the discussion toward identifying specific instructional practices the teacher is already employing and, most importantly, why. By doing instructional rounds within the first few weeks of the program, I have been able to, at least to a degree, more concretely establish a need for the instructional practices we are about to engage with in the coursework. I plan to continue building on these successes to use rounds to focus on specific instructional practices in a more systematic way.

With regard to the development of tools to support novice teachers taking on this challenging work, I have found my attempts lacking. For example, I constructed a tool to scaffold effective openers and closures of lessons. The students found the structure too confining and not flexible enough to fit into all of their practicum contexts. It consisted of categories of information that should be included in openers and again in closures and scripted examples of what this might sound like in the classroom. I wonder what the most effective tool looks like that provides flexibility for the varying contexts that arise in the classroom.

The area of most immediate concern, and for which I have little work accomplished, is the role of instructional practices in evaluation of my novice teachers. As of now, we have no systematic way to evaluate our teachers in a manner I find meaningful. For example, what constitutes successfully 'eliciting students' ideas'? And what variations are necessary to adequately allow for the variations in practice due to the differing contexts (i.e., locality of practice). At this point, the evaluation of my novice teachers is largely subjective and based on their ability to analyze their own teaching in terms of the framework. My next step, in collaboration with colleagues, is to think about a progression across the program for the instructional practices and a final set of criteria that can be used to design a specific evaluation system. This is the final piece to bring coherency across all aspects of the program.

Connection-Making Challenges in AST Implementation

Heather J. Johnson, *Vanderbilt University*

VEXATION

When my pre-service teachers [PSTs] reflect on their science learning experiences in middle and high school, many of them remember teachers who had traditional pedagogical practices – a lot of lecture with I-R-E style discussion. This evokes memories of science instruction as introductions to new ideas as discrete, isolated topics, with no build across days or weeks. If topics were connected, it was because they fell within the same chapter of the textbook. Often the work around these science topics in the classrooms would get so detailed and laden with academic language that they had a difficult time finding any relevance in what they were learning. They could recall the stages of mitosis in sequence and use a mnemonic device to name the planets in order from the Sun. But, the significance of *knowing* these ideas was not always clear, other than to be able to pass a test. Consequently, when they engaged in activities, they did not always understand the purpose of what they were doing. Unless they had a genuine interest in science, they had no big idea framework or larger problem to figure out, so they completed labs, readings, and activities, because they were told to do so. Without a goal in mind driving their engagement with activities (other than a test), they likely missed opportunities to build important connections to their developing network of science ideas.

Despite these memories, I have many PSTs who want to teach science (thankfully!) While almost all of my PSTs enter my program because they have always loved science, I often uncover that many of them did not like how they were taught science in school, or they had one teacher who did it differently and science finally meant something beyond a textbook and they are interested in bringing more of that kind of teaching, that passion for science, into schools. In either case, I find that my PSTs come to me with an interest in learning how to teach science in meaningful, relevant, and important ways. So, I want to support my PSTs in learning how to design opportunities in their lessons for students to engage with science in purposeful ways. Research on units that situate student learning within meaningful goals (project-based learning (Krajcik & Czerniak, 2007), driving questions (Fogelman, McNeill, & Krajcik, 2011), evidence-based arguments (Berland & Reiser, 2009; Reiser, 2004)), shows that when students have a goal to work toward, that goal can be a productive way to help students connect new science ideas to their existing knowledge and can sustain their motivation over a long period of time (Pitts, 2006).

Ambitious Science Teaching [AST] revolves around students making sense of an authentic problem (Lampert & Gaziani, 2009; Newmann & Associates, 1996; Krajcik & Czerniak, 2007). Anchoring events, as described by AST provide a similar goal-oriented opening to a unit because students are presented with a puzzling, interesting phenomenon that they need to scientifically explain (Windschitl, Thompson & Braaten, 2011). As such, I have adopted the AST framework to help my PSTs design and use anchoring events to help situate science learning in more engaging and meaningful ways for their students. However, I find that while my PSTs *like the idea* of using anchoring events to frame a unit, when it comes to practice, they *omit important connections* within and across activities and the larger scientific phenomenon they are trying to explain. The lack of connection-making support interrupts the intended coherence of the lesson design so students continue to experience science ideas as disconnected fragments of information.

Source of Frustration

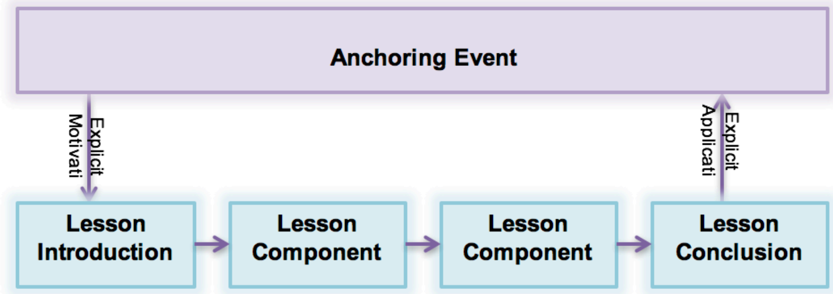
Ideally, the use of anchoring events can facilitate connection-making as students participate in modeling and constructing evidence-based explanations over multiple days. My PSTs use the AST Collaborative Tool (http://ambitiousscienceteaching.org/) to articulate the relationship between the anchoring event and the gapless explanation and explanatory model. However, I find that while my PSTs may have these connections "clear in their head," they struggle to make these connections clear to their students. Based on observations of my PSTs enacting a lesson with multiple related activities, I have found that they assume students will relate specific events in the classroom to the larger phenomenon on their own. However, unless students are told to access their current understanding of the phenomenon while working on the daily activities, students may not attend to or transfer the key understandings from the individual experience to the causal explanation and representation of the phenomenon (Kang, Windschitl, Stroupe, & Thompson, 2016). The wild thing is that my PSTs get frustrated because their students do not "get" the important take-aways from the activities that are needed to inform their explanatory models. Akin to Mrs. Oublier (Cohen, 1990), I find that in my PSTs minds, their activities are sequenced to build on each other and connect to the anchoring event. However, they are not leveraging these connections in ways that could engage students in the science behind the activities.

Implications if not resolved

When students make connections, they engage purposefully with content, draw conclusions from what they did and learned, and integrate these conclusions into their network of ideas that will help them construct a gapless explanation. I know from enactments that use project-based approaches, when the project is established and sustained in this way, less emphasis is placed on the recall of decontextualized scientific facts and more is done to help students develop proficiency in science (Singer, Marx, & Krajcik, 2000; Kanter, 2010; Johnson, 2012). When teachers provide a framework (see Figure 1) that makes the purpose and application of new science understandings explicit, students know why they are engaging with individual activities. In this way, students are supported in developing their understanding of science as a network of connected ideas. The frustrating thing for me is that my PSTs might have this framework in their heads, but they are not making it explicit to their students. So, instead of supporting ongoing changes in student thinking, I hear procedural talk from students engaging in the steps of an activity, but little substantive talk about scientific reasoning.

Heather J. Johnson, *Vanderbilt University*

Figure 1. Representation of places connection-making support could be made explicit for students in a lesson



VENTURE

It is clear to me that my PSTs need to make the connections they have in their heads more explicit to their students while teaching. In the moment of teaching, however, they are more concerned about pacing and management and getting students through the *activities* they have planned. In practice, they overlook the significance of setting a purpose for the lesson or run out of time to debrief the activity with respect to the anchoring event. While my PSTs do use the planning tools and face-to-face tools (Summary Table, for example) in their unit planning process, I find that they need to do something more detailed for a specific lesson. To help resolve this connection-making vexation, I required my PSTs to be explicit about connections between the lesson on the whole and the anchoring event, as well as the connections between individual components of the lesson, in their written lesson plans. My hypothesis was that if they made these connections explicit in the planning process, and included a script with specific questions to help prompt their students to make connections, they would be more likely to be explicit about these connections in their practice.

As part of the planning process, I have added components to the lesson planning template that ask PSTs to do the following:

- ***Provide a lesson overview script:*** PSTs create a script of what they will say at or near the start of the lesson to provide an overview of the lesson that makes explicit what the students will be doing/learning *and why*. The script articulates how the lesson is connected to and builds off prior lessons and learning, as well as to the larger goal of constructing an evidence-based explanation for a complex, puzzling phenomenon.
- ***Provide an explanation of connection:*** After each lesson component, the PSTs articulate how the next component connects to the preceding component and supports ongoing changes in student thinking. They explain how the lesson component engages students in working with conceptual ideas in a way that will allow them to use the ideas to reason about science phenomena.
- ***Transition script:*** Additionally, after each lesson component, the PSTs create a script of what they will say to transition into the next lesson component. They explicitly connect lesson components and highlight the ideas they want students to take with them from one component to the next.
- ***Lesson debrief:*** At or near the end of the lesson, PSTs plan how they will use the time at the end of the lesson for students to discuss how the lesson components help them think about the phenomenon.

PSTs are still learning how to talk to students, much less organize content in ways that are different from district pacing guides and sometimes different than how they learned science. While I feel that making their planning decisions explicit will help them build coherence within and across lessons, I am concerned this approach might be too prescriptive and make the lesson planning process more cumbersome than it already is in pre-service training. I want to give my PSTs the space to engage in this kind of work, but they only have a semester of weekly methods classes to set the AST foundation before they jump into a semester of student teaching. I am hopeful that when my PSTs are more detailed and think more carefully about what they are going to say in a lesson, they are more successful at exporting AST into settings that do not have this in place. I know that helping my PSTs make connections for themselves within lessons and across lessons in a unit is important, but I still struggle with the kind and amount of support to give them. I would like to bring this idea to Crossroads to solicit feedback about this detailed lesson planning approach, as well as collect other ideas that help PSTs bring coherent AST practice into new science classrooms. Below are questions I want to discuss with the Crossroads participants:

- How can I help PSTs understand the importance of making connections within and across lessons explicit to their students? And, are there other activities or experiences that help with this?
- How can I help PSTs follow through with their plans to make connections explicit between activities (a reading, a lab activity etc.) in their enactment?
- How can I help PSTs get their students “thinking” about the purpose of the activity and how it connects to previous activities or an anchoring event before they get their students “doing” the activity?
- How can I press on this connection-making goal when my students are only teaching one lesson per week from a unit that their mentor teacher designed?

Does teaching core practices prepare novice teachers to help the youth from non-dominant backgrounds to learn science?

Hosun Kang, *University of California Irvine*

VEXATION

I am one of the science teacher educators who is experimenting with practice-based approaches to prepare novices for rigorous and equitable science teaching. As an educator who works at a public university and who believes that excellence without equity is privilege, I take promoting equity in my work as my obligation, not an option.

I am experimenting with practice-based approaches using the core practices for two reasons. The first is because I want to make preparatory experiences truly valuable and useful to candidates by attending to the very work of teaching. I have seen the candidates who are tired of reading so many theories that make few connections to their work, just as I myself experienced as a student teacher. In fact, this is one of the problems motivating the current practice-based teacher education (PBTE) movement—the continuous failure of teacher education to help novice teachers to implement ideas advocated by preparation programs in K-12 classrooms — what Kennedy (1999) calls, the problem of enactment. PBTE is characterized as a program's systematic focus on developing teacher candidates' abilities to successfully enact "core" or "high-leverage" practices (Ball & Cohen, 1999). Advocates of PBTE problematize preservice education that focuses on either traditional teaching or theoretical topics that may have only marginal relevance to the realities of the classroom. Traditional preparation tends to focus on observing and analyzing classrooms and teaching, leaving it to novices to put theory into practice Grossman & McDonald, 2008.

The other reason I embrace PBTE is because of my commitment to equity and social justice. The conventional form of science teaching that presents science as final form has left out many youths from non-dominant backgrounds from science. Such forms of instruction inevitably establish asymmetrical relationships of power while privileging a restricted set of practices (e.g., the practices of white, middle class: the practices of western science) foundational to learning. This asymmetrical power dynamic is further exacerbated as race, ethnicity, class, gender, and language play out in an educational setting. Despite the numerous critiques and the decades of school reform in the United States, there are little changes in how students experience science at schools. With my research and educational activities with early career science teachers, I hope to contribute to the transformation of the culture of school science teaching and learning.

After experimenting with practice-based approaches for three years, I have wondered if my goals and choices are self-contradictory. During the first 11 weeks of my methods class, I typically introduce each of the four core practices of science teaching (Windschitl et al, 2012) through modeling, and subsequently engage candidates in the approximation of each practice both collectively at a university classroom and individually at the field site. When I solicited feedback from my students at the end of the fall quarter, many students asked me, "Why are we learning only this one method?" Although I did make a point that the four core practices are meant to be adapted, it seems that many candidates take it as *the* framework of good science teaching. As part of my research, I have been following six case study teachers over the last two years to document their trajectories of practices. During the debriefing interview following the observation of one lesson that was quite impressive, a teacher told me, "I thought you would be so disappointed…because I did not use *your* methods." This new teacher worked with the students who are Latino, bilingual, and from low-income family backgrounds, and who failed prior earth science classes. Although the new teacher did not use the core practices, she was listening carefully and relating students' ideas about the topic, and helping students to approximate scientific practices in a warm, friendly, and supportive environment.

Does teaching core practices prepare novice teachers to help the youth from non-dominant backgrounds to learn science?

Hosun Kang, *University of California Irvine*

Regardless of my intention, it appears that organizing methods course activities to center on the four core practices privileges a restricted set of practices as fundamental to science teaching. Many candidates seem to take it as "the" framework or "Kang's methods," instead of sharing values, theories on students learning and pedagogical goals underlying the core practices. To me, the point of teaching the core practice was not seeing the proof of the core practices in novice teachers' classrooms. Rather, I want novice teachers to take deliberate actions based on *pedagogical goals* that we share and value, such as recognizing heterogeneous meaning-making practices, accommodating the myriad pathways along which learning can proceed (Nasir et al., 2006), and supporting students' identity work (Calabrese-Barton et al., 2013). I concur with Nasir, Rosebery, Warren, and Lee's notion of equity: "*In the end, equity is not about offering or producing sameness, but about enabling youth to appropriate the repertoires they need in order to live the richest life possible and reach their full academic potential*." (p. 499). By teaching the core practices to novice teachers, am I pursuing sameness? Isn't it contradictory to what I want candidates to do with their students? Does teaching core practices really prepare novice teachers to support the students from non-dominant backgrounds (i.e., non-white, multi-lingual, and low-income family backgrounds) by helping them to recognize the necessity and value of heterogeneity?

VENTURE

I intend to re-frame the purpose of teaching core practices to novice teachers. To me, the goal is not to teach the practices themselves. Instead, I would like to create conditions for candidates to learn about students' diverse sense-making repertoires and ways of building upon them with a strategic use of core practices. I conjecture that candidates need the following opportunities to create strong learning contexts for non-dominant background students in their future classroom: the opportunities to: (a) *see* students' diverse ways of meaning-making and its generative power, (b) *experiment* expansive pedagogy that honors and expands students' ways of thinking and talking about the world, and (c) *discuss* students' responses with knowledgeable others to make sense of it. One strategy that I can imagine is using core practice to design "instructional activity" (McDonald, Kazemi, & Kavanagh, 2013). For example, if I design an instructional activity focusing on eliciting students' initial thinking (i.e., one of core practices) with a culturally relevant and contextualized phenomenon, I can use this instructional activity to create a space for candidates to *see* and notice students' diverse ways of making sense of their event. Then, I can facilitate them to experiment this strategy in their field sites tailored to particular learning need of a particular group of students, and make sense of the experiences through collegial analyses of student work and reflection. Will this strategy address my dilemma of using core practices in a way of helping candidates to appreciate plural, multiple epistemologies, and multiple cultural practices? Is it even possible or feasible to enact this strategy given the complexity of preservice teachers' learning ecology that involves so many stake-holders at schools and university?

QUESTIONS TO FELLOW TEACHER EDUCATORS

1. How do others balance between "equity & access" versus "techniques & methods" within preservice course?
2. How do others address the issues of diversity and equity in the context of teaching core practices? What challenges do you encounter and how do you address them?

How can Ambitious Science Teaching be modified for a combined mathematics and science teaching methods course?

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

VEXATION

My vexation concerns an issue that is once again rearing its head as I teach a combined course in science and mathematics methods for secondary pre-service teachers in an accelerated residency program. To state it bluntly, I am still figuring out how the Ambitious Science Teaching approach (Stroupe & Windschitl, 2015; Windschitl, Thompson, & Braaten, 2011; Windschitl, Thompson, Braaten, & Stroupe, 2012) applies to the mathematics teachers in my program. All too often, it feels as if I am shortchanging them when I add the phrase, "…and math!" into each statement about science teaching. My discomfort turns into a vexation as I consider ways to adapt the tools for Ambitious Science Teaching so that they make sense for the prospective math teachers.

The importance of discipline-specific methods instruction has been well-documented in the literature, especially as compared to more general courses that may not address the specific needs in a particular subject area (Clift & Brady, 2005). In our teacher education programs at Montclair State, each certification has at least one course solely devoted to such discipline-specific methods instruction. Mathematics is an outlier in that our two-year secondary math certification program has two methods courses. In fact, a third methods course has recently been added as an option early in the program in order to address the crisis of low PRAXIS II passage rates among prospective math teachers.

The program in which I teach is a bit of an outlier to the more traditional program, in that it is a 13-month residency program, and the "methods" component is not a stand-alone course, but rather it is an integrated part of a larger 11 credit course within the residency (although I receive a 3 credit allocation for teaching it). Consequently, because the residency is a grant-funded program focused on Science and Mathematics teacher preparation, the methods course is populated by both prospective math and science teachers. This year, the class has 13 students (4 mathematics, 4 biology, 3 physics, 2 chemistry).

To a large extent, there is much in a methods class that overlaps between what prospective mathematics and science teachers need from such a course. For example, principles of "backward-design" in lesson planning (Wiggins & McTighe, 1998), the construction of assessments (Wiliam, 2011), and principles of universal design (Hall, Meyer, & Rose, 2012), the use of instructional technology in the classroom (Bruce & Levin, 1997) as well as day-to-day topics about the management and organizations of classrooms can be addressed in a way that cross disciplinary boundaries, including those between the sciences. Unless a university program is large enough to support separate discipline-specific methods classes (which we are not), typically in a general science methods class it is likely that there will be prospective physics, biology, chemistry, and earth science teachers, and accommodations must be made to ensure that each discipline is well-represented. Given the relationship between mathematics and its applications in the sciences, in many cases the pedagogical links are natural and unproblematic, and the congruence between the Common Core mathematics standards and the Next Generation Science Standards creates a much more harmonious methods approach than might be the case if prospective social studies or physical education teachers would have to be accommodated instead of prospective mathematics teachers.

However, given that my approach to preparing science teachers has become more and more strongly aligned with Ambitious Science Teaching, and specifically with the AST tools, I am more aware of gaps in this approach that emerge when working with prospective mathematics teachers, some of which lead to fundamental questions about the nature of teaching mathematics. Some of these questions include:

- What is the role for phenomena and anchoring events in mathematics teaching?
- How do rich mathematical problems—what Jo Boaler (2015) calls "low-floor/high ceiling" tasks—differ from the use of phenomena and anchoring events?

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

- In AST we elicit student ideas as hypotheses for explaining the phenomenon/anchoring events, but in mathematics, is there a better way to frame elicitation?
- How is discourse around mathematical ideas different from discourse around scientific ideas?
- What is the relationship of scientific argumentation to mathematical proofs?
- Is the “gapless explanation” concept portable into mathematics teaching? If so, how?
- Scientific models often include mathematical representation of some sort, but how necessary is the reverse? Is it reasonable to expect mathematical and models to include applications to real-world phenomena?
- Does the “Claim-Evidence-Reasoning” structure hold up across mathematics domains?
- What role ought the more traditional approach to mathematical problem solving and learning algorithms play in an Ambitious Teaching environment? (This still a strong focus for our cooperating teachers)
- What would be the learning goals for mathematics teacher candidates to help them begin their careers as well-prepared beginners, and to what extent are those goals similar or different from the goals for science candidates?

What I am looking for is the set of philosophical guidelines that undergird the Ambitious Science Teaching approach that can be used to make decisions about how best to help my prospective mathematics teachers use core practices concerning the use of big ideas, the deployment and revision of models, and the fostering student-to-student discourse.

VENTURE

The venture I propose consists of moving from my *“…and math!”* approach to a more systematic plan for incorporating the principles of AST into methods. My tangible goal is to revise the four Tools for Teaching Ambitious Science Teaching into four <u>Tools for Ambitious Mathematics Teaching</u> so that they can be used in a combined science/math methods class. My intent is to keep the two versions as philosophically consistent as possible, yet make allowance for the very real disciplinary differences between science and mathematics subject matter areas. My goal is to have these ready for sharing with critical friends by the spring, and to pilot them the next time I teach this course.

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

1. In the broadest sense, is this even a good idea? Is the AST approach exportable to another discipline?
2. What aspects of AST would be important to maintain as these tools are refashioned for mathematics teachers?
3. What aspects of AST seem less important for mathematics teaching?
4. Are there other aspects of mathematical content and discourse not present in science teaching that ought to be included in the revised tools?

My hope is that this venture will reduce disciplinary incoherence in my methods instruction. The broader goal is to foster and extend the use of high-leverage practices into secondary mathematics teaching in order to improve my students’ ambitious practices in their classrooms, and ultimately impact student learning.

Designing Ambitious and Responsive Secondary Science Classroom Assessment Environments for English Learners

Edward G. Lyon, *Sonoma State University*

VEXATION

I came to Crossroads two years ago, somewhat fresh out of grad school and an eager Assistant Professor at a research-intensive institution. My agenda then was to advance a model that represents how assessment can be used responsively for a particular subpopulation of students – English learners. Since then, I have moved to a more teaching focused institution, while still maintaining active research. Per the reason for my move, I now am in a better position to use research as a vehicle to develop collaborations with local schools and within our teacher preparation program to support science education. For one, I have been heavily involved in a NSF grant to prepare secondary science teachers to teach science to English learners. Given this year's theme, I am itching to get back to my assessment research roots and keep thinking about what a secondary science classroom assessment *environment* would look like that is responsive to English Learners in the classroom – namely valuing their linguistic, cultural, and sense-making resources to support their science learning and language/literacy development. The purpose will be to know what happens and what is possible in secondary science classrooms so that teacher educators (myself included) are in a better position to support novice science teachers in implementing ambitious assessment practices. Through data collection of and collaborations with secondary science teachers, I have gained initial insight into how teachers come to make sense of core assessment practices and to what extent these practices are enacted in the classroom (Lyon, under review). For one, I have documented a shift in teachers' assessment activity when engaged in assessment-focused professional development – including better aligned learning goals and evidence for meeting those goals. However, I found it rarer for the teachers I studied to make substantive changes in classroom discourse that would allow student thinking and experience to be made more visible, to integrate and interpret literacy while assessing learning, and provide an explicit support structure for ELs to navigate inherent language demands.

A primary goal of this research was to refine a rubric and protocol that could be used to document varying levels of what I identified as core assessment practices, centered around three dimensions – assessment design, use, and sociocultural considerations. Similar endeavors have been proposed to identify important assessment knowledge and practices teachers should know about and enact (Abell & Siegel, 2011; Siegel & Wissehr, 2011; Webb, 2002), for example (1) assessment purposes, (2) what to assess, (3) assessment strategies, and (4) interpretation and action taking (Abell & Siegel, 2011). Furthermore, teachers' "overarching ideas and beliefs" about assessment are central to guide assessment decisions in the science classroom (Abell & Siegel, 2011, p. 212). I have been inspired by the work on core teaching practices (Windschitl, Thompson, Braaten, & Stroupe, 2012) and seek to extent these contributions to the practice of assessing student learning, including mentorship of novice science teachers.

The fruitful research conducted on formative assessment in science classrooms has led to additional insights for integrating assessment with learning and instruction (Bell and Cowie, 2001; Ruiz-Primo & Furtak, 2007) and even how teachers can work toward more effective formative assessment through learning progressions (Furtak, 2012). Furthermore, studies demonstrate how English Learners' social, cultural, and linguistic background influences their opportunity to demonstrate their content-area learning, often disadvantaging them (Abedi & Lord, 2001; Martiniello, 2008; Solano-Flore & Nelson-Barber, 2001). However, these issues could better be explored through theoretical lenses that provide deeper insight into working with marginalized students. A sociocultural perspective answers this call by taking into account history, cultural, and social practices to understand who learners are and how the situated nature of student experiences in and out of the classroom influence learning. Through a sociocultural lens, assessment would allow student talk, writing, and other public displays of knowledge to become visible and shared with the community of learners (Warren & Rosebery, 1992). In turn, teachers can elicit students' prior and ongoing conceptions, personal experiences, and ways of talking and reasoning to leverage as resources to resemble a culture of sense-making, not just acquiring knowledge.

What vexes me now is how to move beyond narrowly identifying those key features of a teacher's assessment practices. Certainly these practices are critical to leverage opportunities for science learning and language/literacy development, but they are part of a bigger system, an environment, composed of actors, tools, outcomes, and interaction as framed through a sociocultural lens. Could I try to understand how these pieces fit together and what about assessment is really helping English learners? Then, how do we translate this knowledge to our work as teacher educators and respond to the challenges facing novice science teachers? I need to look deeply at the community of teachers and students while this environment is being developed, which might differ between experienced and novice science teachers.

VENTURE

The vexation described above has led me to venture into a proposed two-year study with four high school science teachers (2 experienced, 2 early career) who will participate as individual, albeit interacting, cases to test the theoretical proposition that early career and experienced science teachers can implement a core set of assessment practices that lead to equitable science learning opportunities for ELs. The following research questions, applied to each case, will be addressed in support of the proposition:

- How do the teachers' assessment practices change over the course of the study?
- What factors (e.g., learning and assessment perceptions; collaboration with other teachers; student/school context) constrain or afford opportunities for assessment practices to change?
- In what ways might assessment practice changes shift perceived and observed equitable science learning opportunities for ELs?

Year 1 (2017-2018). The project will begin by observing four participating high school science teachers (2 experienced teachers who have been active mentors of teacher candidates and participated in language-literacy-science integration professional development; 2 early career teachers) across two schools in one school district during Fall of 2017 using a previously developed observation rubric/protocol that documents level of implementing potentially key teaching practices. These observations will be used in part during discussion with teachers to identify what they are currently do, what goals they have for students, and how the assessment environment in their classroom might be refined to be more supportive and responsive for ELs. I will then facilitate a series of discussions, both face-to-face and online, to support teacher development of a responsive classroom assessment environment situated within a unit of instruction, which includes mentorship between experienced and early career teachers. These face-to-face and virtual meetings will be recorded to analyze interactions related to the community of practice. Then, classrooms will be observed as teacher enact their units. Students will also take an opportunity to learn survey to elicit their perspectives of the classroom assessment environment. In addition, a sample of students will be interviewed to elicit both how they make sense of science ideas and to probe for further perspectives of the classroom assessment environment. Participation teachers will also be interviewed for both reflections of practice and perspectives on assessment.

Year 2 (2018-2019). Evidence of practice and student learning will be analyzed and presented to the teachers to reflect on the classroom assessment environment during the focal unit of instruction and refine the environment even further. The unit will then be carried out a second time while collecting the same data sources. The three time periods (Fall 2017, Spring 2017, Spring 2019) provide a baseline and two implementations that can be compared to understand the environment.

Throughout this study, it is anticipated that tools will be developed by myself and the teacher collaborators that have potential use with novice science teachers as well. At Crossroads, I will focus on considering how potential results of this study, included materials developed from it, might best be communicated to and used by teacher educators to support novice science teachers, both in coursework and mentorship during practicum experiences. What would be useful to know by the teacher educator community? What issues are typically faced when discussing assessment with novice teachers, and how might assessment be approached via a deeper connection with issues of cultural and language? By embarking on this venture, I aim to provide deep insight into the vexing problem of how classroom assessment can truly serve its instructional role in linguistically diverse classrooms and ensure novice science teachers are prepared to engage in these ambitious assessment practices.

Uncertain about Uncertainty: Incorporating a Focus on the Reason for Science Practices into my Work with Pre-Service and In-Service Teachers

Eve Manz, *Boston University*

VEXATION

The central vexation that drives my work is this question: How can we design learning environments that are uncertain for students but not unduly uncertain for teachers? I'll start by unpacking this vexation; then I'll discuss how it informs the work I'm doing with in-service elementary school teachers, and end by describing the struggles I'm experiencing in implementing these ideas with pre-service elementary teachers.

Why do I care so much about uncertainty? I am at excited about the potential of our field's current focus on engaging students in scientific practices, particularly how incorporating practices in classroom learning environments positions students as knowledge generators and users, as opposed to performers of facts and definitions (National Research Council, 2012; Rosebery, Warren, & Conant, 1992). However, I'm also worried by the possibility that practices will be instantiated in classrooms as another set of skills that students are directly taught and perform for the teacher or as activities that they are simply directed to do, without any room for decision-making or student agency.

I'm particularly worried about this possibility in elementary school classrooms. The easiest way to introduce a practice such as constructing an explanation or controlling variables is to specify what the practice should look like, model or make it explicit for students, and develop a context where it is easy for students to engage in the practice. These approaches are particularly evident in the design of elementary curricula, which tend to be highly specified, both for students and for teachers. My problem with this approach is that it removes from the learning environment the uncertainty that drives practices in scientific activity. Scientists engage in practices such as argumentation or operationalizing variables in order to impose order on a complex and recalcitrant world and to get others to agree with what they see and what it means (Gooding, 1990; Pickering, 1995). Unless students experience some of this uncertainty, have experience making consequential decisions, and work together to decide what counts a good experiment or evidence to support a claim, they are unlikely to understand the purposes of scientific practices or use them for purposes other than pleasing the teacher (Manz, 2015).

Take for example, the typical case of third grade students using the Wisconsin Fast Plant™ to investigate the needs of plants. Students might be directed to count the number of leaves, flowers, and seedpods and measure the height of plants using centimeter rulers in two specified conditions. While students can see fairly easily that the plants "need lots of light" to grow tall, they rarely talk about what they should count as evidence (does height or seed production matter more?), how the Fast Plant does and does not provide information about the needs of other plants, and how best to represent amount of light. Therefore, there is little reason for them to meaningfully engage in practices such as defining measures, engaging in argumentation, or evaluating models.

One question I have begun to address is how much uncertainty is productive for teachers. While I want to help teachers recognize that it is OK not to know exactly where a lesson is going, and to respond to and build from students' ideas rather than move on to the next idea or skill regardless of where students are, I have also come to realize how important it is for teachers not to experience the same level of uncertainty as their students. It is important for teachers to know what practices they want to develop, have an idea of some contexts where these practices will emerge as useful, and call on a set of teaching moves to translate student surprise, confusion, and disagreement into opportunities for learning. In other words, they should be able to predict something of what will happen when they engage student in uncertain activities and feel confident in their ability to harness those somewhat predictable results for the development of practices and content understandings.

I have a venture in mind for exploring how to support teachers to engage students in uncertain activity while managing their own uncertainty, which I explain below, and look forward to discussing further. However, I am not sure how to incorporate uncertainty and scientific practices into my work with pre-service elementary teachers. As of now, I introduce the practices but always feel they are short changed. I do not know what a well-started beginner looks like in relation to an understanding of the NGSS practices and the conditions under which students engage meaningfully in them. I hope to use the Crossroads conversation to talk about how others are addressing these issues with pre-service teachers and to develop ideas about addressing these issues in pre-service courses.

VENTURE

In order to help teachers leverage uncertainty for the development of practices and content understandings, I think we need to develop a better understanding of specific places in investigations where we could build uncertainty, understand elements of the learning environment that make disagreements, surprises, and confusion visible, and develop sets of strategies that teachers can use to build from disagreement, surprise, or confusion toward approximations of scientific practices. I have the hunch that if we plan a rich investigation well, we could predict something like 60-70% of surprises and disagreements that would emerge and also be able to predict the different approaches students could take to resolving manifest uncertainty. If teachers could anticipate approaches, they could enact a set of strategies that are both responsive to student thinking but also likely to support the development of important practices and content understandings.

In prior work, I have begun to explore ways to open up the experiments that students participate in and increase the uncertainty that they experience. I conceptualize incorporating *productive uncertainty* for pedagogical purposes as opening up science investigations by including opportunities for student decision-making, moments of surprise, and variability in procedures or ideas (Manz & Suarez, Under Review). These are carefully chosen places in investigations where teachers do not explicitly specify what students should see or do, but instead support them to make and discuss decisions. For example, in the Fast Plants investigation described above, rather than telling students what to use as evidence, the teacher could ask students to brainstorm what they might pay attention to in order to decide which plants are doing better (e.g., height, color, number of seedpods). As students draw different conclusions based on different forms of evidence, the teacher might lead a discussion about why students are reaching different conclusions and what evidence is most convincing. Here, uncertainty about the best form of evidence is built into the learning environment to spur disagreement and establish a need for argumentation. In recent work with teachers, I have begun to specify from the outset where productive uncertainty might be built into learning environments: as students discuss a rich phenomenon with multiple plausible explanations, as they plan an investigation, as they interpret data and evidence, and as they apply the results of an experiment to understand the world.

I am beginning the next stage of my work to explore how this model can support changes in teachers' practice. I propose to explore several investigations with groups of elementary school teachers, based on the productive places for uncertainty I've developed. Within each investigation, we would predict productive places for uncertainty, then try them out over several iterations to see what student ideas emerge and what strategies we can enact to capitalize on surprise and disagreement to support scientific practices. I'd also like to know whether we can capture teachers' work in a form (e.g. video case study) that would help another teacher feel less intimidated by opening up the investigation to student uncertainty. I have found that this work must involve explicitly surfacing teachers' ideas of what it means to increase uncertainty for students. I both capitalize on the value that many of them have for open-ended investigations and student choice and help them realize that they don't have to give up all control of the learning environment in order to help students experience uncertainty and engage in science practices. I'm interested to talk with participants at Crossroads about these approaches and get their feedback.

At the same time, I am wondering how to incorporate these ideas into my work with elementary pre-service teachers. I teach in a program that is embedded in a school context and conduct 10 of my 15 days of instruction on-site at an elementary school. At the school, we partner with an elementary science specialist; we coach students and take over lessons in a 45 minute class each week. I have oriented my course around developing core teaching practices to prepare "well-started beginners" (Windschitl, Thompson, Braaten, & Stroupe, 2012), namely supporting pre-service teachers to identify big ideas in units and lessons, elicit their students' understandings, support investigation, and help students develop evidence-based explanations. I begin my course by helping pre-service teachers develop an orientation toward science as sense-making; then discuss and model the core teaching practices. They put these practices into place to plan, rehearse, and enact a lesson in pairs.

Within this model, I am noting several challenges for helping the pre-service teachers value engaging students in rich approximations of science practices, incorporate uncertainty into their lessons, and develop strategies for building from uncertainty to support learning. First, helping my students understand core teaching practices, develop plans, enact lessons, and debrief takes almost all of our one semester together. Every semester I introduce the eight NGSS science and engineering practices and gradually lose focus on them throughout the semester as the lessons take precedence. Second, pre-service teachers seem intent, understandably, on minimizing the uncertainty they face by learning to develop well-paced lessons, provide clear directions, and implement classroom management strategies. Third, they don't have the same resources to draw on to make sense of the value for uncertainty as the practicing teachers I work with: for example, experiences with students' responses to more and less structured lessons and experience teaching the content that could help them anticipate students' ideas.

I'm not sure, therefore, what to aim for in my work with pre-service teachers around the NGSS practices and the role of student uncertainty in students' engagement in practices. I am excited to hear what Crossroads participants think about reasonable goals and ways of supporting both in-service and pre-service teachers. The questions that I would particularly like to discuss include the following:

1. How have the in-service and pre-service teachers that you have worked with viewed opening up lessons to support uncertainty as students discuss a rich phenomenon with multiple plausible explanations, as they plan an investigation, as they interpret data and evidence, and/or as they apply the results of an experiment to understand the world? What have you found to be productive ways to help these two teacher groups see the value of uncertainty and negotiate ideas about how much uncertainty is productive at these junctures in investigations?

2. Are there different necessary beginning points and supports necessary for pre-service and in-service teachers to build uncertainty into investigations?

3. What would count as a "well-started beginner" in terms of an orientation toward student sense-making, the NGSS practices, and the role of uncertainty or student-decision making? That is, what is a useful goal for my elementary methods class that would help pre-service teachers learn and reflect from their first few years of teaching and begin to incorporate more uncertainty for students in their teaching over time?

Science Talk in the Classroom: A Way Into Ambitious Science Teaching?

Kirsten K. N. Mawyer, *University of Hawaiʻi at Mānoa*

VEXATION

Over the last three years I have experimented with ambitious science instruction in my secondary science education courses leading to licensure. During this time I used the Ambitious Science Teaching [AST] Framework, core instructional practices, resources, and tools (Windschitl, Thompson & Braaten, 2012; http://ambitiousscienceteaching.org) and grappled with the question of how to link preservice teachers' [PSTs] field experiences at middle and high school placements with concurrent university coursework. In particular I struggled with how to overcome the potential for mismatch between AST's four core practices' emphasis on teachers' attention to student ideas over time, the structure of my program, and the nature of teaching and learning at field placements. My PSTs are typically in the classroom only one or two days a week. Moreover, during their observations they almost never see expert teachers enact units that engage students in modeling or constructing evidence-based explanations.

AST hinges on designing and implementing thoughtfully crafted units that challenge students to think about big ideas in science through modeling and constructing evidence-based explanations. In order to engage in the core practices of planning for engagement with big ideas, eliciting student ideas, supporting on-going changes in thinking, and pressing for evidence-based explanations, it is essential for PSTs to be in the classroom daily. Without meaningful ways to explore AST core practices at their placements and the requisite "everydayness" of seeing student ideas develop over time, my PSTs have a hard time linking the core practices introduced in methods to their field experiences. Recently one of my PSTs said, "I don't know how to support changes in student thinking because I don't know what the students have been thinking about between my visits and it's hard because most of the time they aren't even dealing with the same concept."

Further complicating the situation, accreditation-required assessments of field experiences prior to student teaching do not align with AST core practices, resources, and tools. In particular, one of the required major assignments meant to bridge methods and practicum is the design and teaching of a lesson plan. At first glance this seems like the perfect opportunity to introduce and experiment with the AST practice planning for engagement with big ideas. In preparation for this design work PSTs read the planning for engagement primer in conjunction with using planning tools. My students spent two weeks using the Collaborative Tool and Card Sort (materials available for download at http://ambitiousscienceteaching.org) unpacking NGSS standards connected to their topic, identifying the relationships between science concepts, and converging on a big idea with the greatest explanatory power. They were excited to move onto identifying a phenomenon, developing a gapless explanation, and putting together an anchoring event in the service of lesson design. Unfortunately, then, the cold hard realization set in—the endgame of planning for engagement with a big idea is designing a unit of instruction and not merely a standalone lesson. Because of the constraints of their field placements, PSTs were not in a position to design a unit, or even consecutive lessons. The task-space available only allowed them to plan a single lesson situated in a unit of their mentor's design. Not surprisingly there was little correlation when students compared their big idea to their mentor teacher's unit. So all of this potentially transformative and meaningful work was for naught in terms of designing a standalone lesson. To ameliorate the situation I ended up reverting back to the non-AST resources and tools I used in previous iterations of my methods course. Fortunately my students were good sports about being sent back to GO without collecting $200. While the class collectively agreed that we learned a valuable lesson about the fact that there are multiple lenses through which teachers can frame conceptually big ideas, there was an undercurrent of confusion about the connection between planning for engagement and lesson plan design. As an instructor I was left pondering my naive assumption that core AST practices could be used unproblematically across my methods and practicum courses and whether some practices or components of practices were a good fit for my methods-practicum pairing.

VENTURE

As a starting point for the venture of developing coherent and connected methods and practicum courses I analyzed each of the practices that make up AST to look for commonalities. I hoped doing so would guide decision-making about how to maximally use limited time in the field to prepare PST for working with the entire Framework and core practices during student teaching the following semester. My goal was to develop *pedagogies of enactment* that closely couple methods coursework with the more performative aspects of teaching (Grossman, Compton, Igra, Ronfeldt, Shahan, & Williamson 2009; Grossman & McDonald, 2008; Kazemi, Franke, & Lampert, 2009). This close inspection revealed that science talk is an essential foundational practice that drives ambitious instruction (Figure 1).

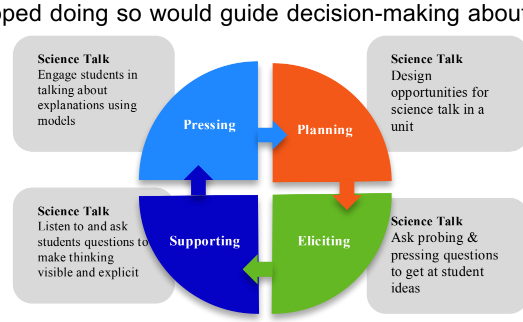


Figure 1. Role of Science Talk in AST the Framework.

In order to learn, science students, along with their teachers, need to talk science in the classroom, communicate in the language of science, and participate in a community that engages in talking science (Lemke, 1996). It follows then that science talk, an inherently sociocultural (Lave & Wenger, 2002; Rogoff, 2008) and situated cognitive (Greeno, Collins & Resnick, 1996) endeavor, could operate as an excellent entry point for bridging the methods fieldwork divide.

Creating opportunities in every lesson of a unit of instruction for students to engage in science talk is a key feature of the design work involved in the practice of planning for engagement. In the absence of productive science talk it seems almost impossible for PSTs to learn and implement AST's high-leverage instructional practices [HLP]—eliciting ideas, support changes in thinking, and pressing for evidence-based explanations (Windschitl, Thompson & Braaten, 2012). Though AST does not explicitly identify science talk as an HPL independent of the four practices, current definitions of what constitutes an HLP suggest that science talk is one in its own right (Grossman, Hammerness, & McDonald, 2009).

Even though my PSTs do not have the opportunity to design and implement an AST unit in methods or the luxury of being placed with a practicum mentor who is familiar with AST, I can reliably count on my PSTs having access to instruction centered around hands-on "inquiry" science activities. While the vast majority of these activities are procedural in nature that does not preclude me from leveraging them as an opportunity for students to explore science talk as an HPL. During these activities my PSTs have the opportunity to interact and more importantly talk science with students one-on-one, in small groups, and occasionally as a whole class. In any of these interactions, PSTs can practice talk moves and while not responsible for designing activities they provide a chance for them to flex their discursive muscles.

I have found that concurrent methods coursework in which students are introduced to AST framework with a focus on science talk, along with aligned field assignments allow PSTs to develop a pedagogy of enactment (Table 1). The sociocultural approach in which teacher candidates engage *in situ* with science talk through a combination of legitimate peripheral participation, apprenticeship, guided participation, and participatory appropriation situated in a nascent community of practice and expert practitioners (Greeno, Collins, Resnick, 1996; Lave & Wegner, 2008, Rogoff, 2008) allows PSTs to become familiar and comfortable with scaffolding and facilitating science talk with actual students.

Table 1 Aligned methods coursework and practicum assignments targeting science talk

Methods	Practicum
I teach an AST Unit with PSTs as learners	PSTs evaluate context for learning and expectations for participation and behavior.
I use the discourse primer (AST, 2015) to introduce science talk, teacher talk moves, higher cognitive demand questions/tasks	PSTs record and analyze science talk at placement paying particular attention to norms of participation, questions, and student thinking
PSTs read Eliciting Student Ideas Primer (AST 2015) and Clinical Interviews (Russ & Sherin, 2013), develop clinical interview using higher cognitive demand questions/tasks	PSTs conduct and analyze clinical interview which provides initial opportunity to engage students in productive science talk using probing & pressing questions
We watch expert videos (National Board ATLAS Library, AST Video Gallery) to analyze science talk paying particular attention to norms of participation, questions, and student thinking	Video club: PSTs formulate and ask back-pocket-questions during activity group work in the field. They video record and analyze science talk in a video club during methods class sessions
PSTs read Supporting Ongoing Changes in Thinking Primer (AST, 2015) & Just in Time Instruction, whole class video club analysis using RSST	
PSTs read Group Work (AST, 2015) and transform procedural activity to intellectual activity by creating opportunities for productive science talk whole class video club analysis using RSST	PSTs record mentor teaching procedural activity and analyze science talk
PSTs design formal lesson plan with intellectual activity with opportunities for productive science talk	PSTs teach formal lesson plan which includes intellectual activity. Record and analyze science talk

I have found that by the end of the semester PSTs are able to design a lesson in which they modify and transform a procedural activity into an intellectual activity by creating opportunities for science talk. PSTs' video analysis has shown that they are able to engage students in productive science talk. Given my program constraints, I believe the best possible preparation for student teaching occurs when my PSTs earnestly engage with the AST Framework. My hope is that by the end of student teaching, my PSTs are able and excited to design and implement AST units as they move into their role as classroom teachers. That said it seems unreasonable to think that novice teachers can design and implement back-to-back-to-back AST designed units in their first years of teaching. My goal is that the emphasis on science talk in methods and practicum and subsequent design and implementation of an AST unit during student teaching will translate into the first glimmer of expertise in which looking for and creating opportunities for science talk becomes second nature to the point that these emerging practitioners are able to fluently access teacher moves that support science talk during formal and informal planning and preparation, as well as on the fly instruction in their daily teaching practice (Bransford, Brown, & Cocking, 2000). I want them leaving with an AST focus on science talk.

Creating opportunities for student talk while planning for instruction, and designing lessons and AST units, requires constantly asking questions such as: Where are my students engaged in intellectual work? How can I design effective group work that supports student thinking? How can I avoid prolonged lectures and traditional initiation-response-evaluation interactions? How can I purposefully select or design higher cognitive demand tasks or transform procedural activities? I've posited that science talk is an HLP that can operate as a viable entry point and pathway for ambitious science instruction. Even so there are a number of questions that are worth further discussion:

- What AST practices should we have our PSTs engage in across methods and practicum when they are not in the field daily?
- Are some AST practices more important than others?
- Are there other HLP, like science talk, that are embedded or hidden in the AST framework?
- Does focusing on an embedded HLP, like science talk, in methods and practicum constitute AST?
- Is focusing on science talk the right lever for where PSTs are in their professional trajectory?
- Are there activities or experiences I can include in addition to video club, clinical interviews, and questioning in the field to connect science talk more directly to AST practices?
- What are other entry points into AST that could bridge the university coursework-field divide?
- What are the most important AST takeaways for PSTs preparing for their first years of teaching?

New “ways in” for examining systemic inequity in K-12 science classrooms

Rosemary Russ, *University of Wisconsin, Madison*

VEXATION

Art/graffiti on UW Madison’s campus in Spring 2016. The artist/perpetrator was a student of color, arrested by police with guns drawn in the middle of class in a University building.

There are two truths that perpetuate my life as a science teacher educator and researcher. First, I live (and breathe!) in a world in which systemic racism is pervasive. Second, my elementary science methods courses consist nearly exclusively well-meaning, upper-middle class, white women. These two truths together present a challenge that is more problematic than any other I encounter in teaching. How do I support my students in making substantive progress towards equitable, ambitious science teaching when their experience of the world does not match the reality of inequity surrounding them?

Like many of my colleagues, I have tried a number of “ways in” to help my students think about inequity and their role in perpetuating or dismantling it. First, I have engaged my students in explicit conversations about their local social climate, specifically around overt instances of racism and religious intolerance. This “way in” gives students who have been minoritized and dehumanized a chance to share their stories and shifts the dynamic of whose voice matters in my classroom. But it also has the challenges that students from dominant groups do not know how to engage productively with the conversations and it feels disconnected from their K-12 classroom experience.

Second, we explore systemic, institution-level inequities around race, religion, and sexual-orientation by examining statistics from the Southern Poverty Law Center (2016) or the GLSEN National School Climate Survey (2013). This activity heightens awareness of the larger landscape of inequity we create and often fuels a desire for my students to become agents for change. But the connection between individual prejudice and systemic discrimination is a non-trivial link for some, and further these statistics do not provide any guidance for how to become agents of change.

Third, we discuss surveys such as “Unpacking the Invisible Knapsack” (McIntosh, 1988) and others that have been created for middle/upper class, religious, gender, cis-gender, and heterosexual privilege. These types of surveys shift the conversation from the visible experience of the subordinate to the invisible experience of the dominant and in doing so expose the racialization of society as well as non-racial privilege. However, these surveys can create a paralyzing wall of guilt among dominant groups such that the connection between privilege and action is not clear.

There are pros and cons to each of these approaches, but an additional con is that none of these “ways in” unfolds organically from a specific focus on science learning. While that fact doesn’t bother me, my students have often complained “what does this have to do with science teaching?” My students want to engage in equitable, culturally responsive science teaching, but they have a hard time reconciling “science” pedagogies such as High Leverage Practices intended to support all learners (Lampert, 2009) with “equity” pedagogies such as Culturally Relevant Teaching intended to support minortized students (Ladson-Billings, 1995).

My experience of this vexation is exacerbated by my (embarrassingly) recent recognition of my own positionality and subjectivity (Peshkin, 1988). I grew up in the Southeastern United states where “race” was a bad word, and talking about race was considered impolite and racist; we were color blind in the worst possible sense. Further, my interest in science education grows out of a background in science (my PhD is in physics, not education). As such, my focus has traditionally been on helping students and teachers come to a better understanding of (positivist) scientific epistemology (Rudolph 2002). Only since working around Gloria Ladson-Billings and Michael Apple have I begun to understand the internalized dominance and systemic privilege I (and the domain of science itself) carry at all times. This emerging identity helps me recognize how the scientific epistemology I cared so deeply about is bound up with who gets to count as a knower – which is an inherently racialized question. And it is that racialized question both I and my methods students must grapple with if we are going to create equitable classrooms (even if we are using HLPs!).

VENTURE

I stumbled into my “venture” quite accidentally. My interest was largely in epistemology (Hammer and Elby, 2002) and the ways teachers engage in the ambitious practice of attending and responding to their students’ ideas (Robertson et al., 2015). My focus was on whether teacher attention sends tacit meta-messages to students about the nature of science learning and the role of their ideas in that learning (Russ et al., 2009), and how those messages support students in adopting epistemologies that were productive for science learning (Russ, 2014; Russ & Luna, 2013). To scaffold pre-service teacher (PST) attention to these messages, my colleagues and I (Berland, Braaten, & Russ, NSF, 2013) engage our PSTs in traditional video club-style questions (van Es & Sherin, 2008) around video of student science discussions. Like many of our colleagues, we discuss the student ideas in the video, how PSTs would respond to those ideas, and what are the pros and cons of those responses for the teacher. However, we go one step further and ask our PSTs: If you were a student in this classroom, what would (2) tell you about the value of your ideas in the science discussion? These discussions proved to be quite rich, and our PSTs talked in sophisticated ways about potential epistemological messages associated with their pedagogical decisions (the final question) (Russ, accepted).

Then one of my PSTs turned this conversation from scientific epistemology to epistemological equity. We were watching a video about seeds growing in sand in which the teacher does not acknowledge or respond to one Latino student's (Bryant's) idea. As a class, we had discussed the other rich student ideas and some potential teacher moves. When we got to answering question 4 around a potential teacher question, one of my students said "Does Bryant feel the same way about those questions I guess?" His comment stopped me in my tracks; he was saying that he couldn't answer the question of "If you were any *random student* in the room what would that teacher move tell you about your ideas?" because different students might feel differently about the value of their knowledge.

Science educators such as Bang and Medin (2010) have brought our field's attention to this fact many times - some students' (and groups of students') knowledge is valued more than others even before that knowledge has been made public. Philosophers use the notion of epistemic injustice and oppression to describe this phenomenon. When Bryant's class fails to give him the credibility he is warranted, they (a) wrong him in his capacity as a knower (Fricker, 2007), and (b) hinder his ability to contribute to or communicate the knowledge production of the community (Dotson, 2013). There are a variety of negative consequences for this type of epistemic injustice both for the individual who is wronged as well as for the epistemic community itself.

My student's comment made me pause: Could I use a question focused on whether teacher moves value student ideas as a space to talk not only about scientific epistemological messages but also about epistemic injustice? Could this be a "way in" for talking about the systemic inequity pervasive in schools and yet challenging to make tangible for my young white novice PSTs? For example, as my student pointed out, Bryant is a traditionally minoritized student; ignoring his comment may serve to perpetuate – rather than dismantle – the system of privilege that excludes Latino student's knowledge and ways of speaking from what counts as "scientific." Over the last semester I have tried this out with modest success. For example, in one such discussion the issue of equality vs equity came up quite organically when a student asked:

> What about [if your teaching move] brought the kid down? Like he was quieter because he didn't have the answers any more? Is that okay because he is normally the guy that talks all the time? And now you are leveling it out. Because if he talks in science he's probably also the one talking in math, he has the answer in math. He can still feel validated in math… Is it alright if he comes down? How does that dynamic work?

These conversations are productive because they are clearly connected to my PSTs science-specific classroom practice, they provide tangible, in-the-moment action for my PSTs to take, and the interactions in which epistemic injustice is present are observable in video and thus available for joint conversation and reflections. They allow us to discuss (in)equity at the level of individual interactions, which moves us beyond talking about the spirit of the high leverage practices and towards the specific ways they can either perpetuate or dismantle privilege. However, these discussions may lead to assumptions and stereotypical assertions about the needs of minoritized students. I have only just begun this work, and there are a number of questions I struggle with:

1) What is the "goal" of these discussions? What does "sophistication" in navigating epistemic injustice look like?
2) How will I know whether my PSTs have learned anything? Where will I see evidence of change?
3) How do these discussions support (or not) the work on High Leverage Practices? Is epistemic justice inherently part of HLPs, and – if not – what would it take (theoretically and practically) to make it so? Is it even possible?

Using the Interpretive Dance of Discussion to Support Student Science Learning

Danielle K. Ross, *Northern Arizona University*

VEXATION

Our students must be held accountable to authoring, constructing, and developing their own ways of making sense of scientific concepts and phenomena. By using the scientific practice of modeling and problematizing a phenomenon, connecting prior knowledge, and giving students the authority in their own learning, a teacher can effectively use discussions in the classroom to engage students in productive and rigorous sense making (Engle & Conant, 2002). As we know, thorough planning and preparing for a rigorous science discussion is one of the most important ways teachers can support sense making in science (Stein et al, 2008).

Oftentimes planning and implementing a classroom discussion is overwhelming for preservice teachers and many often resort to not using open dialogue in the practice of modeling as a main means of instruction. In order to make preservice teachers more comfortable with enacting these discussions in their classrooms, we as teacher educators need to attend to specific aspects of this core practice and help novice teachers develop the skills to enact productive discussions, while providing them opportunities to approximate the practice at varying levels of authenticity (Grossman, et al., 2009).

In order to support preservice teachers' facilitation of rigorous science discussions, I have worked over the past several years with the *Five Practices* model for orchestrating productive discussions (Cartier, Smith, Stein, & Ross, 2013; Smith & Stein, 2010; Stein et al., 2008). This model is a useful pedagogical framework for teacher educators to use in their work with teachers to help them learn how to plan for and facilitate a discussion more effectively by asking teachers to anticipate student thinking and ideas, monitor students during group work, select students to present their ideas, purposefully sequencing the students' ideas, and connecting the ideas through discussion.

The techniques used to engage teachers in learning how to use the Five Practices effectively seem to vary between individual teacher educators. I utilize Grossman et al. (2009) framework for approximating practice to provide opportunities for students to rehearse the individual practices in the first of two methods classes. While approximating this core practice in the methods class gives the preservice teachers some practice, it is important for them to approximate these discussions with real students in science classroom. Ideally, I imagine opportunities where my preservice teachers can observe expert teachers utilizing the model in their own classrooms, or at the very least, supporting student talk. Often this is not the case, my preservice teachers often observe their mentors engaging their students in low cognitive demand tasks and activities many times with no grounding in scientific phenomena. Moreover, many mentors are at the very least willing to have a preservice teacher in their classroom, but do little to support the student beyond giving them a space to "practice."

Our graduate program typically works with the same teachers year after year and there does not seem to be any change in the mentors teaching. While it seems wonderful in theory to work with the same teachers, the mentors seem to view their role as the "real world" experience instead as a two-way opportunity for learning. Mentors are willing to provide the preservice teachers with a space to see "what teaching is really like" instead of working to understand what we are asking of the preservice teachers. For instance, my presevice teachers are often asked to do their teaching episodes or lessons when the mentor is absent so that the teacher will not have to make substitute plans or miss a day of their lessons. Furthermore, it is very frustrating for me to hear my preservice teachers say that they aren't learning anything in their practicum placements after a few weeks except for what not to do.

With these ideas and issues in mind, my vexation is: ***How do we support preservice teachers in engaging students in rigorous classroom discussions?*** I believe a discussion focusing on this question is significant for our community of teacher educators. Much focus in science education recently is on supporting students' in developing models for explaining phenomena. I believe that utilizing the Five Practices model is one way to support discussions about students' models. As a field we have done much work on these core practices of teaching, I continue to ponder ways in which to effectively combine this core practice and this scientific practice together to improve science teaching.

VENTURE

The Five Practices Model is purposefully designed to support teachers in designing learning experiences for students where teachers can elicit students' thinking, plan to support students' engagement in science ideas, and support students' sense making. For myself, I see the Five Practices Model as a pedagogical tool for teachers to support them in meeting the goals of ambitious science teaching. By selecting or designing a high cognitive demand task and supporting classroom discourse over the course of a few lessons, this grain size seems to be more manageable for teachers to implement instead of unit-level learning experiences.

In my methods course for secondary science teachers, we spend a great deal of time, 4-5 weeks, decomposing, representing, and approximating the Five Practices. My students work on anticipating students' ideas and thinking about a task/question, as well engage in coached rehearsals in monitoring, selecting, sequencing, and connecting. I wish we could spend more time on unpacking these practices, but I must also include lesson planning, opening and closings, and just-in time instruction with coached rehearsals in the 15-week semester. The way the course is designed right now, at the end of the semester, my students teach a "Five Practices Discussion" in their practicum placements. Unfortunately, more times than not, my preservice teachers must fit their lessons in a two-three week time frame and the tasks designed by my students are not cognitively demanding and do not support a rigorous discussion. The reasons for this vary, but three issues resurface every year. First, the mentor teachers provide the activity or task and the students must teach this task. Second, my students plan a rigorous task, but it appears to fall apart during enactment. Third, my students have only one opportunity to enact this type of discussion in classrooms because of time constraints.

I am currently working on ways to support my preservice teachers in designing tasks that allow their students to engage in the science practices. However, my greatest issues are that I am not certain how to engage my student teachers in a combination of these practices and I have not been able to provide authentic opportunities to plan and teach in this way outside our methods course. I continually ask myself how we can simultaneously support mentor teachers as well as preservice teachers. Flagstaff is a small town with limited secondary science teachers and an even smaller group of science teachers willing to take on a practicum student. I want to find ways to support mentors in understanding how to engage students in rigorous discussions in order for my preservice teachers to see this modeled in an authentic setting. I have seen success with some of my preservice teachers who try to utilize the Five Practices during instruction. But, the failures seem to outweigh the successes at this point.

The Five Practices is designed for a sequence of lessons often three-four days and can be utilized by teachers in supporting their students' modeling. The question is how. How can we support teachers in seeing how the pedagogical model of the Five Practices can be used to support students' classroom discussion? My next step is to work with colleagues to work incorporating the Five Practices into their methods courses. I look forward to a productive discussion on ways to support preservice teachers in facilitating rigorous science discussions more effectively and more often.

Wasting precious time: The affordances and constraints of a 2-year ambitious methods course

David Stroupe, *Michigan State University*

> And now I come to a red-hot question: How about those
> terrible methods courses, which waste a student's time?
> *The Education of American Teachers* — Conant, 1963

Or to put it another way:

> I ain't sayin' you treated me unkind
> You could have done better but I don't mind
> You just kinda wasted my precious time
> But don't think twice, it's alright
> *Don't Think Twice, It's All Right* — Bob Dylan, 1963

VEXATION

I am not the first person to use Conant's quote to open a conversation about methods courses (see Grossman et al., 2009) and their significance in the life of preservice teachers. I am perhaps the first person to note that Bob Dylan echoed the similar sentiments in the same year. The punchline of Grossman's use is that Conant calls into question the courses supposedly most related to the daily work of classrooms. Conant's argument has been taken up in various forms and provided a foundation for the "learning on the job" mentality of many alternative certification programs. In essence, methods courses should be minimized as much as possible (so as not to waste a student's time) so that they can get to a classroom faster (e.g., Teach For America and the Relay Graduate School of Education).

My gut reaction to the sentiment of "wasted time" is twofold. First, I do not want to be a teacher educator who is complacent in a system that requires preservice teachers to pay money but receive poor training. In other words, I need to provide preservice teachers with valuable learning opportunities so they feel that their time and money is well spent. Second, I think that the "wasted time" paradigm emerged from a theory of teaching and learning that focuses on instruction as information delivery and learning as the recitation of canonical facts. In such a framing, methods classes may not provide much help given the limited vision of a teacher's daily work.

My work with ambitious science teaching (AST) – an instructional framework focused on a core set of four high-leverage practices that facilitate rigorous and equitable learning opportunities for all students – suggests that a methods class could be crucially important for a preservice teacher. They need multiple opportunities to see teaching, unpack the parts, and rehearse practices over time.

My vexation, then, is to better understand how to use the precious time I have so that I help preservice teachers learn ambitious instruction. While many teacher educators face a time crunch (perhaps one semester of methods), I have different situation – an abundance of time. I have preservice teachers for six hours per week during their entire senior year (2 semesters of 4 hours of class, 2 hours of lab per week), and 3 hours per week during their year of student teaching (I see them almost every Friday). One feature of this extended time is that the teacher education program is supersaturated with concepts, assessments, and benchmarks.

While this may not seem initially problematic, I am now attuned to my instruction and preservice teacher needs in ways I could no be in shorter methods courses. I the past, I was lucky to get through the four practices of AST (Big Idea, Eliciting Ideas, Supporting on-going changes in thinking, and Pressing for evidence-based explanation) through modeling and microteaching. My hope now in my current situation is that preservice teachers take up most/all of the practices as they enter student teaching.

In my current situation, however, I think I can extend my expectations for preservice teacher learning while still not wasting their time. My vexation, then, is wondering what and how I should recalibrate. Some questions include:

- What is important about AST beyond a surface-level enactment of the practices?
    - Can we really get into equity?
    - "Noticing" student thinking?
    - Students taking up epistemic agency?
    - Negotiating "what counts" as science practices

David Stroupe, *Michigan State University*

- What does "advanced" AST look and sound like (in a methods class)?
- What about preservice teachers who do not take up AST (or take up pieces) – how can I get them on board?
- What is my role as a teacher educator now?

VENTURE

I propose the role of the teacher educator is to provide opportunities to learn for novices in much the same way that teachers provide them to their students. The difference is that teacher educators must create situations that allow novices to both rehearse the practices required of inservice teachers, and understand why such pedagogical practices are crucial for supporting student learning. However, the field of teacher education knows very little about the pedagogy or content of courses that focus on the practices of teaching.

Because I have a unique opportunity to see preservice teachers develop over an extended time period, I think I should study my methods class. I engaged in a brief study (with my co-instructor Amelia Gotwals) that resulted in "macroteaching" – an extended version of "microteaching" that allowed teams to teach an entire unit of instruction to their peers. While promising, I think that macroteaching is the tip of the iceberg. With so much time available, I think I can help preservice teachers take on more complex work that I currently think is possible. I am unsure of what work entails. However, I know the onus is on me to provide preservice with novel learning opportunities while simultaneously examining and adapting such opportunities given the data I collect.

One consideration is how I might conduct research and collect data that is meaningful for the field. Can/should I make claims about how to use time in teacher preparation program if the sample size is one?

IDEAS I HAVE CONSIDERED

1) I frame my work through an "inquiry stance", meaning that I critically reflect on my methods pedagogy while examining the experiences I design to support the emerging needs of my students (Cochran-Smith & Lytle, 2009). As a course designer and researcher, I try to be systematic about documenting the learning of preservice teachers and myself, taking into account multiple perspectives, decisions, and dilemmas (Cochran-Smith and Lytle, 2009).
2) I am familiar with ideas of "noticing" from mathematics education (e.g., Sherin et al., 2011) and treating students' ideas as resources. I wonder if there is something I can contribute beyond the typical use of videos to help preservice teachers pay attention to student thinking.
3) In the final semester of student teaching, the preservice teachers conduct participatory action research in which I co-design research with them that they can conduct in their student teaching placements. The research emerges from the preservice teachers' problems of practice. It is possible that such research could be the basis for a NSTA presentation, Science Scope/Science Teacher article, and (maybe) a NARST presentation/JRST paper.

QUESTIONS FOR MY COLLEAGUES TO CONSIDER

- What directions are important in teacher education around AST that I could address – what do we need to learn more about?
- What are the limits of AST in a methods class – how far down the rabbit hole can preservice teachers go?
- Who can preservice teachers become in a methods course? Able or "well-started beginners" and (or?) agents of change ready to dismantle teaching and learning norms on day 1 in a classroom?
- How far down can I go? What else do I need to learn about AST to provide preservice teachers with deeper learning opportunities?

Generating Resources, Tools and Activities – Without a Theory?

Mark Windschitl, *University of Washington*

VEXATION

Every year I have the privilege of working with a new cohort of aspiring secondary science teachers. I have my novices read important articles on instruction and learning, engage them as science learners, model ambitious science teaching practices for them, support them as they try out complex practices for themselves, and offer feedback regularly. In the process, I feel like I have some influence in helping them become well-started beginners. What I feel less confident about are the articulations between the university coursework and their clinical placements in public schools.

Over the years I have become aware of the dramatic variability in these placement opportunities. Some of my student teachers report amazing experiences in which they see rigorous and equitable practices play out with real students. Their cooperating teachers share what they know about establishing relationships with students, about planning, instruction, and assessment. They allow their student teachers to experiment with strategies they've been taught at the university. Other novices, however, are in very different situations. They can experience frustration at seeing young learners do little more than take notes, day after day, and witness the inevitable disengagement that results. Most of my novices enter their clinical experiences with the intention of putting everything they've learned in their preparation program into practice, but for a variety of reasons they have limited opportunities to do that. To be clear, my vexation is not about the generous CTs who volunteer their time and give up their classrooms. It's about making that partnership more productive. We know from research that cooperating teachers have a significant impact on the thinking and practice of novices, but we also know that opportunities to learn for novices are shaped primarily by the past experiences, skills, and worldviews of these mentors (Ball, Sleep, Boerst, & Bass, 2009; Deussen, Coskie, Robinson, & Autio, 2007; Little, 1990). How, then, can we support all the actors in this system that need to work together more productively (novices, CTs, university instructors)?

We may have some clues about where to begin. Our research group at the University of Washington recently finished data analysis from Year 1 of a study that examines the clinical experiences of novices from four different university-based preparation programs. Each of these programs foregrounds Ambitious Science Teaching as the framework for instruction. What we have found so far has illuminated where missed opportunities might be reversed, as novices learn how to use the AST framework with students and get support from their cooperating teachers in the process. The data gave us "good news / bad news" results. For example, we found almost no instances of novices sitting down with their cooperating teachers and talking about their own beliefs and practices around planning, teaching, or assessment. This meant that there were no opportunities for novices to understand what principles were driving the day-to-day decisions of their CTs, or for CTs to hear about the stances that novices were taking on these aspects of professional work. Another tentative finding was that feedback on lesson design and debriefing of teaching for many of the participants was nearly always at a general level. Cooperating teachers at the end of lessons would ask, "What went well?" or frequently focus on classroom management issues at the expense of commentary on students' ideas and equitable participation. On the other hand, some CTs had debriefing questions that catalyzed new insights for their novices and posed questions they could try to answer—as a team—about student learning in their shared classroom.

VENTURE

I and my colleagues at the University of Washington are thinking about a next round of projects that can build upon what we've learned from our current studies of the clinical experience. We are in need of a theory for how learning can be supported in school apprenticeships where AST can be risky to try out because it looks so different from common teaching practices. We don't have this theory yet, we are not even sure that apprenticeship, in the traditional sense, can be used to describe what goes on. We are, however, making headway around resources and routines that can address some of the problems we see in helping novices bridge the university experience with the clinical experience. My questions for Crossroads colleagues are: Should we begin to develop this suite of "solutions" before we come up with a theory for how and why clinical experiences actually function the way they do? What might be missing from the following list that could be helpful? How can we assess the fruitfulness of these changes in terms of learning by both novices and the cooperating teachers?

Guide for action. Our first possible resource is simply a one page guide for CTs that explains in clear terms what AST is, what practices one might expect to see in a classroom where AST is being used as the framework for teaching, and how different aspects of AST (planning, use of discourse, tools for making student's thinking public, etc.) are beneficial for young learners in terms of rigor and in terms of equity. We do not think this, by itself, would have a decisive impact, but we do feel it will increase the probability that CTs will at least understand what the big principles are that underlie AST and get a sense of how novices have been prepared at the university.

Supports for teaching conversations. A second resource we can imagine is a set of supports for how to have a conversation (between CT and novice) about why some forms of instruction, planning, and assessment are particularly valuable for students' learning and participation. In nearly all of the clinical experiences of our Cohort 1 participants, they and their CTs tended to talk "around" these issues, never addressing why certain decisions were made and leaving unspoken many ideas about professional work that would be better made explicit and open for discussion. We are not sure if a set of questions or sentence frames would be helpful here, or videos of these types of conversations.

Trying out pieces of AST. This resource would define activities that novices can try out in small "pieces" of AST without teaching full lessons. They can, for example, circulate during small group work to talk with students, getting to know how young learners think and respond to instructional tasks. Novices can try out discourse moves to help students reason and to talk to one another. These situations we see as valuable because they allow novices to devote their attention to challenging aspects of teaching (for example, responsive and equitable discourse) without having to attend to issues such as management, distribution of materials, transitioning to the next part of class, etc. Novices could also run warm-ups, design exit slips that probe students learning after lessons, experiment with scaffolds for reading or talk, write assessment questions, create modeling templates, or volunteer to create anchoring phenomena for units.

Collaborative collection of classroom data. Because the apprenticeship involves two adults in a classroom, there is an opportunity for one of them to make observations about the types of scaffolds or teacher moves that can encourage students to engage with the work and with each other. This would entail the collection and analysis of data around student participation, by either the CT or the novice. The CT and novice can explore improvements in their practice (for either of them), determine what kinds of data would provide evidence of positive student responses (observations of student talk, exit slips from students, etc.) then collect and analyze this data, and talk about the implications for future instruction. This might generate conversations about what kind of data is worth collecting and why, which can lead to frank conversations about why participation by all students is so important.

Supporting self-advocacy by novices. In our current project we heard little from the novices about how they exercised advocacy for themselves. We didn't hear much at all about negotiating with their CTs what kinds of experiences they wanted to have in the classroom or what opportunities they felt were important to them. In most cases, novices fell into patterns of co-teaching or co-planning that seemed sensible to their CTs, but that were not influenced by the short term or long-term goals of the novices. Explicit goals for professional learning, in fact, did not seem to figure into CT-novice conversations very frequently, if at all. We feel that advocacy for one's self and for certain goals may be crucial for a successful apprenticeship, but our puzzle is how to theorize about this (is advocacy, in and of itself important, or does it support other opportunities to learn) and how to build the skills and dispositions for self-advocacy in novices.

We view these resources and activities as a package that works together to support novice opportunities to learn. None of the parts of this system would have to be particular to a preparation program; the package could be developed and tried out in a number of institutions with regular iterations of refinement and dissemination. We don't know, however, how we might collect data on the effects of this project. Would we get self reports from novices? Interview CT's? What would constitute progress? This last question is one that I would really love some input on. We imagine that if we were to fashion a suite of such resources, that they would be applicable to any preparation program in which AST is foundational to the work that novices bring into public school classrooms. If we could begin to share and test these resources together, we may be able to form a community of teacher educators for which continual improvement of the clinical experience is the goal.

Craftwork as a Language for Teaching

Nate Wood, *North Dakota State University*

VEXATION

My vexation emerges from a general concern with the fragmentation of knowing in Western thought. At least, that has become a unifying concern around which a bunch of other things I have been pondering coalesced. Crawford (2009) points to the adoption of Taylorist ideas about so-called "scientific management" as a critical transition point in dehumanizing the nature of work because it's that production is made more efficient by preventing physical laborers spending time thinking about what they are doing. Instead, the job of management is to analyze a production process, so that it can be optimized – by breaking it down into discrete steps. Unlike skilled craftspeople – who have deep understanding of materials, techniques, and processes needed to create a whole product – laborers in a Taylorist system need only be proficient at the procedures needed to carry out their step in the process reliably. Taylorism segregated thinking from doing. And after decades of indoctrination, we have come to imagine a natural split between thinking versus doing – or, more apropos to preparing science teachers, theory versus practice. Applied to schooling, I think Taylorism has de-professionalized teaching. What I see in Crawford's account is a powerful alternative to fragmented ways of knowing: craftwork. I want to make the argument that teaching, properly conceived, is craftwork.

I have come to conceptualize craftwork as the integration of experiential knowing (know-how) with intellectual knowing (know-that). Thus, I see craft as different from both expertise (as it is conceptualized in academic literature) and pedagogical content knowledge (PCK). The research I've seen suggests part of what characterizes expert performance is automaticity: experts recognize problem contexts holistically and respond without needing to think consciously about how or why. In other words, it seems to me that expertise is a primarily experiential way of knowing. On the other hand, framing PCK as a type of knowledge (noun) seems to me to gesture toward it being a primarily intellectual way of knowing (surely this is true pedagogical knowledge and content knowledge). To be clear, I don't mean to diminish the value or worth of intellectual or experiential ways of knowing. Rather, my goal is to draw attention to how wide the chasm has become between those ways of knowing – and name craft as a bridge between them. Perhaps a couple of examples will clarify what I mean.

Craft is the difference between an artist's idea for a painting and the painting itself (Sennett, 2008). Even with a clear vision in mind of how the final product is to look, a painter has numerous decisions to make about how to create it: what medium to use as the substrate, what type of paint, what type of brush, which techniques to apply the paint, in what order to create different elements in the scene, etc. Certainly, skilled painters draw from experience to make many of these decisions – and execute particular techniques with automaticity – but experience alone cannot provide a step-by-step recipe for producing a unique work of art. An artist must make numerous conscious decisions about modifying or combining familiar techniques to create new effects. Neither careful reasoning-about nor application of well-practiced techniques can independently yield a unique painting. Works of art are crafted. They result from the integration of thinking with skillful application of methods. Craftspersons reason-through the application of their technical skills. But I don't want to give the impression that craftwork is only associated with art. Artists are craftworkers – but not all craftworkers are artists. Carpentry, computer programming, writing, teaching, and countless other human endeavors, done well, are crafted.

Pirsig (1974) makes an important distinction between what I would call a garage mechanic and a factory trained technician. Factory training typically involves specific procedures to affect specific, routine repairs. Factory-trained technicians are supplied with factory-produced shop manuals, which prescribe diagnostic procedures and streamline routine repairs by detailing every step in the process – even stipulating how much time each step should take. They minimize thinking and maximize doing. Garage mechanics, on the other hand, are "self-taught" (read: they make LOTS of instructive mistakes on their own, which they are sometimes mentored-through by more experienced colleagues – especially when they get really stuck). Starting from a conceptual understanding of how the machine works (each manufacturer designs and constructs things differently, but most are based on a few, common, underlying concepts) they gather information about symptoms, develop hypotheses about what malfunctions may cause those symptoms, test those hypotheses, refine diagnoses, etc. There is some doing involved in all of this - but there far more thinking. The upshot is, for a comparable repair, garage mechanics are usually slower than factory-trained technicians. But a good garage mechanic can fix anything – because they reason their way *through* the task. They are craftworkers. In contrast, a factory-trained technician can typically complete a given repair much more quickly – but only if it is covered in the manual.*

I am vexed, generally, about the cultural blindspot that has emerged for the distinction between craft and technique. And in the context of this year's Crossroads theme, I worry science teaching, science teacher education, and even the preparation of science teacher educators has become a primarily technical endeavor. I would like to explore whether craftwork can provide a language for thinking more ambitious ways of doing science education.

Craftwork as a Language for Teaching

Nate Wood, *North Dakota State University*

VENTURE

My fledgling venture that connects to this year's theme is to do with leveraging the practitioner-focus of the EdD degree to craft mentorship for future teacher educators. Essentially, I'd like to re-imagine how we craft mentorship of future faculty members who will craft programs to prepare science teachers to craft instruction in science. (It's craftwork all the way down!)

As part of our participation in the Carnegie Project on the Education Doctorate (CPED), NDSU has been working on making a meaningful distinction between our PhD and EdD degree programs in education. There is a contentious issue here. Prominent voices in our field have been advocating to abandon the EdD degree altogether because, as they are typically constructed, EdD degree programs tend to amount to "PhD-lite." However, while I think the clear-cut researcher (PhD) versus practitioner (EdD) distinction being made by CPED is problematic (because it embodies the very fragmentation that vexes me), I do think it is useful to recognize some difference here. I see the relationship of PhD to EdD as being parallel to the relationship of science to engineering. They are inter-related in that they involve a shared knowledge base. But they are distinct in that one orients primarily toward advancing/refining that knowledge-base, whereas the other orients primarily toward putting that knowledge to use to meet existing human needs. This is an over-simplification, of course, but it seems to me that it would be fruitful to recognize that the nature of the craft of educational research (inquiry) is different from the nature of the craft of educational practice (design). Both are essential to the functioning of a healthy community of educational scholars – but I think they entail different skillsets. Thus, I would like to like to use the incubator session to think through implications of conceptualizing the EdD degree as a mechanism to prepare future teacher-educators and providers of professional development as scholar-practitioners. Instead of maintaining traditional models of doctoral education, designed to prepare educational researchers, might the flexibility of a practice-focused doctorate better prepare scholar-practitioners to craft more ambitious and responsive programs for preparing more ambitious and responsive science teachers?

Thus far, I have worked with only one doctoral advisee who completed what I consider to be a proper EdD dissertation. I will spend some time, during the incubator session, unpacking that experience, because it was radically different from other experiences I've had mentoring doctoral students. And it provides a jumping-off point for imagining how an EdD program can look. However, the kinds of questions I am keen to explore include:

- What still needs to be done by way of conceptualizing craftwork? I have tried to distinguish craftwork from expertise and PCK. Is the distinction compelling? What other concepts does my notion of craftwork need to be distinguished from?
- Does naming what teachers do as "craft" open more natural connections to apprenticeship models of education? Are there things we can learn from other fields where apprenticeship is done well?
- What kinds of experiential knowledge do practicing science teachers bring to doctoral study? Are there certain kinds of experiential knowledge that should be pre-requisites for admission into (EdD) doctoral study?
- How is theory done differently in crafting educational practice compared to crafting educational research? Are there implications here for the kinds of mentorship EdD scholars need?

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* This is an overstatement of the situation. I suspect nearly all mechanics first develop their interest as a result of experiences in their own (or others') garages. These days, most people who fit the definition of "garage-mechanic" I am offering here are amateurs. Those that decide to become professionals need to participate in factory training in order to become employable. So it is probably more accurate to describe the situation as a continuum ranging from technician-like (factory-trained) to craftsperson-like (garage-mechanic) approaches to the work. I'm making an artificially-sharp distinction in hopes it will clarify how I am thinking about craftwork.

Building Adaptive Capacities of Novice Teachers Through Exploration of Adaptive Capacities of Social Ecological Systems

DeeDee Wright, *Poudre School District*

VEXATION

Immediately upon [walking through their own classroom door], teachers are expected to be leaders in their classrooms, schools, and communities so they can develop their own students' knowledge, skills, and attitudes. Paradoxically, novice teachers' own knowledge, skills, and attitudes may still be in formative stages when they begin their teaching careers. Novice teachers begin developing knowledge, skills, and attitudes (about the needs of diverse learners and who can pursue STEM professions) during their teacher preparation program, and these cannot be expected to be fully developed by the time they embark on their professional careers in the classrooms. Hence, my vexations: *How do we collaboratively build a bridge from the formal teacher preparation (apprentice) to a novice teacher (journeyman)? How might empowering novice teachers enable them to, in turn, become ambitious teachers and leaders (masters), then empower their own students and mentees to pursue lifelong learning, all with limited time and resources?*

As a science (and interdisciplinary STEM) teacher educator I think about four areas of growth that are important for new teachers: 1) **content knowledge**; 2) **disciplinary competency**; 3) **academic confidence**; and 4) **academic capacity**. There is much research on pre and in-service science teacher professional development over the past 20 years centering on the first two attributes. Helping college students earn degrees in disciplinary content and advocating opportunities for them to participate in authentic scientific research (as undergraduates or teachers) are goals that many of my teacher educator peers strive to achieve. More recently, though, we have started developing programs to build disciplinary competencies in communicating science, constructing evidence-based arguments, and unpacking what "quantitative reasoning" means. This is great—we are expanding what "disciplinary competencies" means. *Is it too ambitious to ask novice teachers to integrate these four areas?*

The research thus far indicates that novice teachers, especially those in urban, rural, and underserved communities, leave the teaching profession (or schools where students are most at risk for dropping out). Many researchers claim that teacher educators need to attend to students' discontentment, help teachers question their biases, and strengthen teachers' commitment to working in challenging schools. *And how can this be achieved? What role does Ambitious Science Teaching play?*

I know (and am vexed) that emphasizing disciplinary knowledge and competencies is not enough to keep novice teachers feeling fulfilled, grounded, and ready to be teachers of diverse learners, if teacher educators do not also attend to pre-service teachers' academic/professional confidence and to their academic/professional capacity. The list of expectations and requirements grows! To be successful and to stay in teaching jobs, teachers must: 1) teach their students about how knowledge is generated/nature of science (NOS); 2) meaningfully integrate science/math knowledge so it is grounded in real-world experiences (beyond memorizing disconnected facts); 3) value (and actively seek out) students' prior and cultural ways of knowing about the world; 4) develop their students' communication competencies; and 5) build their students' confidence, positive attitudes, resourcefulness to stay in school, stay in STEM classes, and continue studies post-HS.

This is a tall order and ambitious order; how do we do this?

Building Adaptive Capacities of Novice Teachers Through Exploration of Adaptive Capacities of Social Ecological Systems

DeeDee Wright, *Poudre School District*

VENTURE

To find solutions, it makes sense to draw on our own knowledge, competencies, confidence, and capacity. Dr. Meena Balgopal will co-design a venture around what we know, love, can do, and have done with Andrea Weinberg and Laura Sample McMeeking, who are collaboratively running our institution's Noyce Program, and DeeDee Wright, a veteran science teacher (24 years)/Noyce coordinator/graduate student. We are redesigning a professional development (PD) model for novice teachers but are wrestling with goals that capture all of the elements novice teachers need to develop the knowledge, skills, and attitudes to be successful in the complex system of a classroom, which exists in a larger system (e.g., school, district, community, and state).

Social ecological systems (SES) theory describes and explains that socio-economic systems are coupled with bio-physical ones. Although the environmental education community has been modifying their definition of ecological literacy to assume that humans are a part of and affect environments, the environmental or natural resource management (NRM) community is only just now adopting this construct. NRM professionals are tasked with helping communities adapt and build resilience to address local and global environmental issues, including those related to agro-ecosystems, urban ecological systems, climate change-related resource availability, food insecurity, etc. We believe that the education community can learn from the interdisciplinary community by bridging different philosophical and practical approaches to solve problems in sustainable ways. Therefore, we venture to use the environmental science/natural resource management construct of SES within the Ambitious Science Teaching (AST) model to address our vexations in STEM teacher education.

We propose that our Noyce STEM teacher education program design place-based, resilience-centered PD for pre-service teachers (who have already decided to teach in high-needs schools/communities) that allows them to develop: NOS and content knowledge, strategies to include multiple funds of knowing, communication skills, and confidence in becoming a civically engaged STEM student. We posit (or hope) that by helping teachers find the connections between **RESILIENCE** in environmental/ natural resource management systems (**CONTENT**) and teaching/ supporting student learning (**PEDAGOGY**), new teachers will build their own confidence and competencies (**ADAPTIVE CAPACITY**) to thrive and persist in communities where there has historically been high teacher turnover (**DYNAMIC LANDSCAPES**) resulting in **SUSTAINABLE** changes that benefit students.

Designing curriculum as part of a pre-service/ PD program is not enough, though. Our team must ensure that each pre-service teacher is partnered with a teacher mentor, who can encourage and help them, as they become novice teachers, identify local partners and mentors. As soon as our novice teacher graduates become immersed in their new communities, they need to find resources to help them feel anchored, and then only can they begin to help their own students develop the same capacities. The opportunities to identify local problems that rely on creative and varied knowledge (scientific, historic, local, cultural, etc.) will provide a platform to build students' appreciation of authentic science, community pride, civic engagement, and confidence. Issues may be grounded in the schoolyard (e.g., problems of pigeon guano), neighborhood (e.g., litter and related health hazards), or community (outbreaks of insect pests and pathogens). Part of the challenge will be for novice teachers to immediately draw on the expertise of their students to identify local problems and find a local mentor to help them persist in their endeavor. This requires a vulnerable disposition as one crosses ambitious bridges to build individual professional capacity that, in the long run, can empower everyone!

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