Teaching Statement
Brian M. Donovan

Overview. I believe that effective science curriculum and instruction can be guided by multiple theories of learning. In my opinion, the choice of one theory over another in the design of learning should be guided by the purpose of the learning and the particular challenges students face when learning in different domains. If, for example, learners are engaging with phenomena where there are strong pre-conceptions, such as the physics of falling objects, then instruction designed on the basis of conceptual change theory, or Piagetian constructivism, might be warranted. However, if the objective is to help students construct meaning from a text, then literacy-based instruction guided by socio-constructivist ideas may be more appropriate. Finally, if the purpose of learning is to engage students in practices such as the analysis and interpretation of data or scientific argumentation, then a situated perspective on learning might be the best way to help students become competent users of these scientific practices. My pluralistic stance on science teaching and learning is founded upon the assumption that, at present, there is no universal theory of how people learn, or for that matter, how people behave in learning situations because teaching and learning are complex cultural endeavors. That does not mean that all theories of learning are equally valid or that there is no basic knowledge about how to design effective curriculum and instruction. Instead it means that the task of the expert is to determine which theories of learning are applicable in which learning situations. In this teaching statement, I explain my philosophy on effective curriculum and instruction in K-12 science teaching and also my framework for science teacher education. Then I provide an example of how I use different learning theories and instructional tools to design science teacher education courses aligned with my philosophy on K-12 science teaching.

K-12 science teaching. Effective curriculum and instruction in science requires instructional coherence, assessment of student thinking, attending to learners’ prior knowledge and experiences to help them construct new knowledge, and accounting for motivation and student identity. Regarding coherence, effective science teaching involves the design of objective driven lesson plans through backwards planning frameworks. These lessons should form an overarching science narrative that targets an essential question that is meaningful to students and based in the core ideas of a discipline. Ideally, the big ideas in such lessons should be taught in a way that makes them relevant to students’ identities to activate their motivation to learn. Motivation can be accomplished in many different ways, but I try to establish motivation by anchoring learning in a phenomenon or problem that is relevant to student identity. Thus, a core aspect of teaching is that teachers know their students. Regarding assessment, science instruction should begin with a pre-assessment of the learner’s prior knowledge because new knowledge is built upon, contrasted with, and constructed upon the learner’s previous knowledge. During the course of instruction, teaching should be guided by embedded formative assessments. At the end of instructional units, students should have an opportunity to demonstrate their understandings through a performance assessment that requires them to apply newly constructed knowledge in a novel circumstance. Each of these phases of teaching should provide students with feedback on their learning either through the use of rubrics or through written and spoken feedback framed by a “growth-mindset” perspective that values effort, repeated practice, and perseverance.

Science teacher education. As a science teacher educator, I design and teach courses modeled on my K-12 science curriculum and instruction principles. The big ideas that organize my teacher education curriculum are the goals of science education (e.g. democratic, cultural, utilitarian, or economic imperatives for teaching science), assessment of student thinking, instructional coherence in curriculum design, instructional tools based in learning theory, disciplinary literacy, and equity in science education. The tools that I use to support the learning of these ideas are video analysis, reading and discussing instructional dilemmas in teaching cases, curriculum and assessment critique, reflecting
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on personal science learning. Using these tools, I provide opportunities for teaching candidates to build new knowledge through argumentation, discussion, debate, and academically productive talk.

An example. I would begin by asking teachers to design, implement, and analyze responses to pre-assessments so they can learn about the knowledge of their students in a domain that is relevant to their student teaching. On the basis of that learning, I would organize teachers in groups to write objective driven lessons aligned with 3-dimensional NGSS instruction. I would provide teachers with scaffolds to help them design lessons that build upon students’ prior knowledge and experiences. I would further support this learning with video-into-practice professional development materials, such as the STELLA protocol, which has been shown to improve PCK by helping teachers notice instructional coherence and/or identify how students think. I would also support this learning by having new teachers read and debate instructional dilemmas related to their teaching using the teaching cases in WestEd’s Making Sense of Science curriculum. Then, as a class, we would brainstorm ways to anchor the learning in the developing lessons with a phenomenon that is motivational. Finally, we would critique each lesson to improve it and assess how it embodies principles of learning theory.

As argued in the introduction, many important theories exist. When I introduce new teachers to a conceptual change model of learning it is to help them understand how to design instruction when there are strong pre-conceptions about a phenomenon. For example, objects of different weights do not fall at different rates, thus, it is important to help pre-service teachers understand how to design lessons that help students revise their naïve concepts of gravity. During those lessons, it is also important to introduce critiques of conceptual change theory and to actively mitigate against deficit theories of ‘student misconceptions’. I would also introduce new teachers to inductive learning strategies at this point, such as Schwartz and Bransford’s (1998) time for telling framework.

At the same time, not all science concepts should be taught through purely cognitive approaches to learning. On the social side, the construction of new knowledge is shaped by language, identity, and a sense of social-belonging in the culture of the science classroom. The learning of science is a form of situated cognition, where the cognitive work of each learner is situated in the cultural and linguistic setting of the science classroom. Therefore, effective science instruction introduces students to the conceptual tools of science through the language of science. It educates children about how scientists write scientific texts, how they read scientific texts, and how they argue about scientific ideas.

Thus, I believe that good science teacher education must model and explicitly teach new educators how to design literacy-based instruction. This means helping new educators move away from instruction based on a transmission model of education that is defined by an initiation-response-evaluation model. It means moving teachers toward a model of instruction where students can talk about, write about, and represent their knowledge. Consequently, as a science teacher educator, I regularly teach and model instruction on: (i) academically-productive talk; (ii) the difficulties of reading science texts and how to teach reading in science to promote argumentation and debate (see: http://serpmedia.org/rtl/index.html); (iii) how to write to learn science by engaging teachers in various writing scaffolds, such as Brian Hand’s science writing heuristic; and (iv) how to support the writing of scientific arguments and explanations with drawing, reading and talking scaffolds.

In each lesson, I always create a time for a science learning activity. I might ask teachers to collect, analyze and/or interpret data from their own study, an available data set, or a computer simulation (e.g. https://phet.colorado.edu/). Teachers would then be asked to construct a model that explains their data. Then, they would be asked to argue with one another to create a consensus model that best explains all the data. As a group, they would critique each other’s arguments by questioning the methods, evidence, or reasons used by each research group during a gallery walk activity. After, we would reflect upon the lesson to understand how learning was designed to engage them in NGSS practices such as argumentation or using models. At this point, I would assign readings on Cynthia
Passmore’s model-based reasoning tool, Jon Shemwell’s work on helping learners to abstract models through analogical induction, and work on argumentation by Jonathan Osborne, Kate McNeill, and Victor Sampson.

As teaching candidates learn how to scaffold these types of instruction, I would begin to introduce ideas of equity in science education. Science teachers need to develop an awareness of how hidden cultural biases affect the teaching of science. I typically introduce this idea by having teachers watch videos (e.g. tools for ambitious science teaching videos) where science teachers show a clear bias of calling on boys in classroom discussions. At this point, I would assign readings that deal with equity in science education, such as work by Okhee Lee, Glen Aikenhead, Julie Bianchini, Bryan Brown, Megan Bang, Marcia Linn, and my own work when it is relevant. Then, we would use these ideas to analyze and critique the lessons we developed earlier in the semester to make them more equitable, and/or culturally responsive. I elaborate more on my approach to teaching equity in science education in the diversity statement that follows this teaching statement.

At the end of this learning, teachers would have developed a series of lessons that could be combined into a coherent mini-unit for a state credentialing performance assessment. The performance assessment for my science teacher education course would be this mini-unit. Students would be given a rubric for their final projects that includes dimensions on equity, disciplinary-literacy, learning theory and instructional scaffolds, assessment, and 3-dimensional NGSS instruction. After scoring their own unit and critiquing the work of others, they would revise their work and hand in the mini-unit as the summative assessment for the course.