Fundamental Challenges to Learning to Teach Science as Practice

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Abstract: We report a case study of 3 teachers working together to learn to teach science as practice that demonstrates fundamental challenges for teacher learning. One is a lack of a clear understanding of science practice as distinct from school tasks. A second is the struggle to link science concepts to the phenomena in the world they explain. A third is a need for effective strategies to support productive student talk.

Introduction

Science teachers in the United States are currently working to adapt their teaching practice to the demands of the Next Generation Science Standards (NGSS Lead States, 2013). The standards were developed from a framework (NRC, 2012) that advances a view that can be labeled ambitious science teaching (Windschitl, Thompson, & Braaten, 2018). Windschitl and colleagues' notion of ambitious is primarily that students have the lion's share of responsibility for developing their conceptual understanding through regular cycles of modeling and investigation that allow them to refine their ideas over time. Teaching science in ways that support students taking on primary responsibility for figuring things out places a number of demands on teachers that have been emphasized in the rollout of the NGSS. One is that the core science practices should be the means through which students develop their conceptual understanding. Another demand is that students' understanding of core ideas should be oriented toward explaining phenomena in the world, which requires high levels of coherence in curriculum and instruction. A final demand is that classroom discourse become fundamentally dialogic and student centered.

We describe the efforts of a team of 3 high school science teachers learning to revise their practice through a 3-year professional development program structured around sustained support for revising their curriculum.

Study context

Alison, Anne, and Karen (pseudonyms) taught at two different schools in the same district serving a K-12 population of about 32,000 students, 96% of whom identify as Latinx. Karen and Alison taught at a comprehensive school with just over 2500 students in grades 9-12; 87% of whom qualify for free or reduced lunch, and about 20% are classified as English learners. Anne taught at a continuation school with just over 350 students; of whom 71% qualified for free or reduced lunch, and nearly 27% were classified as English learners. Karen, Alison, and Anne collaborated to develop two units that we observed and video recorded in their entirety. The fall unit asked how wounds heal, as a basis for learning about cell division and differentiation. The spring introduced the case of a young girl who nearly died from antibiotic resistant MRSA to ask are bacteria good or bad?.

Method

Here, we are interested in understanding how participation in this PD program changed teachers' teaching, particularly in relation to goals aligned with the NGSS, via two questions. Were units consistently, coherently linked to anchor phenomena? If so, this would suggest teachers had learned to re-orient their units toward the world. Were students being engaged in science practices as the means through which they developed their conceptual understanding?

We use a method to characterize lessons and instructional units in terms of coherence, by looking at whether lessons are *linked* to each other and whether they are *anchored* clearly in the focal phenomenon. We also characterize three aspects of instruction. One is teacher *framing*, referring to how the teacher orients the lesson or task relative to the anchoring phenomenon of the unit. A second aspect is the locus of epistemic *agency*, referring to who has authority and accountability to evaluate what counts as knowledge in the classroom (Elgin, 2013). The third aspect is the *version of practice* students are engaged in: whether tasks are open-ended and how much task procedures or methods are up to students. Agency and version of practice are conceptually related, but we interpret agency in relation to students' opportunities to interpret information for themselves, to disagree, and to talk through disagreements, and versions of practice attends more to the structure of given tasks and the opportunities in them for students to decide how to do their work (cf., Ford, 2005). Each aspect is scored independently as either oriented toward school (-1), toward the world (1), or somewhere in between (0).

Findings

The scores for each unit by each teacher are shown in Table 2. Several patterns can be seen in these scores, showing both differences between the three teachers' enactments of the same unit, and across the two units.

Table 1: Proportional scores for aspects of instruction for three teachers units in fall (F) and spring (S). Pds reports the number of lessons in each unit as taught by each teacher

	Pds		Anchored		Linked		Framing		Agency		VoP	
	F	S	F	S	F	S	F	S	F	S	F	S
Karen	7	5	1.00	0.80	1.00	0.25	1.00	0.60	0.43	-0.20	0.43	-0.40
Alison	8	9	0.63	0.22	0.43	0.25	0.00	0.33	-0.13	-0.67	-0.13	-0.67
Anne	9	6	0.56	0.67	0.50	0.60	0.44	0.33	0.33	-0.17	0.22	-0.33

Coherence

Fall units were generally anchored to the wound phenomenon, but spring units were much less anchored except for Karen. Generally, teachers did not consistently link lessons to prior ones.

Science orientation

Karen and Anne are more consistently oriented toward what we consider authentic science than Alison, for both units. Yet, Karen and Anne struggled to maintain this orientation in the spring bacteria unit than they did in the fall. Alison's lessons show that anchoring phenomena were employed mainly has hooks into canonical science "content." Karen and Anne, however, tried to reorganize their units as efforts to explain the anchoring phenomena, and their struggles to do so consistently reflect the difficulty behind this reorganization.

Consistent framing to the natural world

All of these teachers were more successful in framing students' activity toward their anchoring phenomena than in the other two aspects. The spring unit presented difficulties in framing lessons consistently toward the anchor phenomenon, mostly because teachers chose to use labs they already knew could demonstrate natural selection but were not clearly related to bacterial resistance, or even disease.

Limited access to practice

The *agency* and *version* scores in Table 2 show also that students had limited access to genuinely scientific practice and limited epistemic agency. Even when lessons were framed toward anchoring phenomena, the tasks given to students were limited.

References

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