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Instructional Practices in Secondary Science: How Teachers Achieve Local and Standards-Based Success

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OVERVIEW: Teachers can support three-dimensional science learning by using instructional practices that engage students in sensemaking about phenomena and cognitive apprenticeship, and through strategic sequencing of divergent and convergent classroom discourse.

AUDIENCE: Curriculum designers; teacher educators; instructional researchers; secondary science teachers

KEY POINTS

- Teachers' local success, including effective management, engagement with content, and efficient grading, is a necessary foundation for students' three-dimensional science learning.
- Activity-based teaching—relying on pace and novelty for motivation, activities that cover the curriculum, and grading based on participation and completion—enabled local success but not three-dimensional science learning.
- Sensemaking about phenomena and cognitive apprenticeship teaching strategies, with strategic sequencing of divergent and convergent classroom discourse, enabled both local success and three-dimensional science learning.

INTRODUCTION This article reports on analyses of the instructional practices of six middle- and high-school science teachers in the United States who participated in a research-practice partnership that aims to support reform science education goals at scale. All six teachers were well qualified, experienced, and locally successful—respected by students, parents, colleagues, and administrators—but they differed in their success in supporting students' three-dimensional learning. Our goal is to understand how the teachers' instructional practices contributed to their similarities in achieving local success and to differences in enabling students' learning, and to consider the implications of these findings for research-practice partnerships.

FINDINGS Data sources included classroom videos, interviews with teachers and focus students, and examples of student work. We also compared students' learning gains by teacher using pre-post assessments that elicited three-dimensional performances. Analyses of classroom videos showed how all six teachers achieved local success—they led effectively managed classrooms, covered the curriculum by teaching almost all unit activities, and assessed students' work in fair and efficient ways.

There were important differences, however, in how teachers engaged students in science practices. Teachers in classrooms where students achieved lower learning gains followed a pattern of practice we describe as *activity-based teaching*, in which students completed investigations and hands-on activities with few opportunities for sensemaking discussions or three-dimensional science performances. Teachers whose students achieved higher learning gains combined the social stability characteristic of local classroom success with more demanding instructional practices associated with *scientific sensemaking* and *cognitive apprenticeship*.

More successful teachers emphasized continuing storylines in their teaching. They often opened lessons with divergent discourse as students made sense of phenomena in their own terms, then used consensus-seeking group work and discussions to move toward convergent conclusions.

More successful teachers also emphasized student writing. They assigned three-dimensional sensemaking tasks, saved students' initial ideas and questions and returned to them later, scaffolded complex writing; encouraged editing in small groups, and graded three-dimensional writing performances

TAKEAWAYS The *Carbon TIME* project was a partnership including experienced teachers who achieved local success (including expectations around management, content, assessment, and grading) and researchers who were familiar with instructional design principles for standards-based success (including sensemaking and apprenticeship instructional practices). Some details are complex, but the main findings of this study can be simply stated:

- Teachers with high student learning gains achieved both local and standards-based success.
- Teachers with high student learning gains strategically facilitated both divergent and convergent classroom discourse.

Implications for researchers and teachers in research-practice partnerships include the importance of (a) sequential timing of divergent and convergent instructional practices, (b) taking student writing seriously, and (c) teachers developing expertise in both sensemaking and apprenticeship strategies through professional learning that is sensitive to the requirements of local success.

The results identify instructional practices that recognize the purposes and insights of both researchers and teachers—whose collaboration and cooperation will be essential for long-term improvement in science instruction and science education outcomes supported by research-practice partnerships.

Carbon TIME instructional materials, assessments, professional learning materials, and research reports are on our website: https://carbontime.create4stem.msu.edu/

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