Educative curriculum materials and the Next Generation Science Standards

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What are educative curriculum materials?

Educative curriculum materials are designed with the intention of supporting teacher learning as well as student learning. They include the base materials designed to support student learning *and* educative features designed to support teacher learning (Davis & Krajcik, 2005). Educative curriculum materials can support positive outcomes in terms of preservice and practicing teacher learning, teacher practice, and student learning in science (e.g., Arias et al., 2016; Arias et al., 2017; Beyer & Davis, 2009; Bismack et al., 2015; Cervetti et al., 2015; Kademian et al., 2017; Loper et al., 2017; McNeill, 2009; Pringle et al., 2017; Roseman et al., 2017; Schneider & Krajcik, 2002) and other subjects (e.g., Collopy, 2003; Drake et al., 2014; Grossman & Thompson, 2008; Hill & Charalambous, 2012).

Why is it important to make instructional materials educative for teachers?

All students deserve opportunities to engage in rigorous and consequential science learning, and the Next Generation Science Standards put forward a vision for what that might look like. Yet the new standards, in some ways, make all teachers novices (Zembal-Saul, personal communication, April 2017), because the vision requires sophisticated knowledge and teaching practices not familiar for most teachers. The vision emphasizes making sense of phenomena through three-dimensional learning that integrates science and engineering practices, crosscutting concepts, and disciplinary core ideas (NGSS Lead States, 2013; NRC, 2012). Educative curriculum materials provide one way to support teacher learning to work toward this vision. These materials can promote learning within different domains of teacher knowledge, support the development of science teaching practices, and give teachers images of new ways of teaching.

Educative curriculum materials may be especially crucial for elementary teachers of science. Elementary teachers teach all subject areas, including all science disciplines, but may not have robust science knowledge (e.g., Abell, 2007). They are unlikely to have had the kinds of bench science experiences that might help teachers develop familiarity with science practices. Professional learning opportunities for elementary science teaching are also limited (NASEM, 2015). Furthermore, elementary science traditionally has had an activity focus that lacks orientation toward sensemaking (Appleton, 2002). Thus, educative *elementary* science curriculum materials may be particularly important.

What might educative curriculum materials look like?

To support the vision of the NGSS, educative features must help teachers:

- develop knowledge about the vision of the NGSS, including understanding the disciplinary core ideas, crosscutting concepts, and science and engineering practices themselves; knowing what is meant by three-dimensional learning; and recognizing the need to support rigorous and consequential learning for *all* students,

- learn *how* they can engage in teaching that works toward that vision—through recommending approaches that can promote this more sophisticated learning, and
- gain images of what this kind of teaching that prioritizes sensemaking could look like, ideally across a range of classrooms that represent some of the variety of backgrounds and experiences of students and teachers across the United States.

Thus, teachers need support in understanding disciplinary core ideas, crosscutting concepts, and science and engineering practices themselves, as well as what it means to integrate these in their instruction. Some of the educative features that we have incorporated as a means of working toward these goals have included (Davis et al., 2014):

- unit concept maps and core ideas maps
- content storylines (descriptions within each lesson of how the lesson extends the learning from the previous lessons and supports the future learning)
- content boxes that explicate specific disciplinary core ideas within a lesson and how the content ideas are worked on within three-dimensional learning
- features to help teachers recognize why a particular science practice is important in a lesson and giving suggestions for how to support students in engaging in it
- reading and discussion guides
- guides for anticipating students' ideas
- rubrics that show what effective engagement in a science or engineering practice looks like in conjunction with a disciplinary core idea, with sample student work
- narratives that describe how a fictional teacher (based on our observations in classrooms) adapted a lesson and why she made the choices she did.

Cervetti and colleagues (2015) developed research-based educative features aimed at supporting teachers in promoting science learning among their English Language Learner (ELL) students. For example, some educative features focused on how teachers could use cognates to help Spanish-speaking ELLs to access unfamiliar English words, and others explained idioms that might be confusing to ELLs.

McNeill and colleagues developed multimedia educative curriculum materials with a mix of text- and video-based educative features (e.g., Marco-Bujosa, McNeill, González-Howard, & Loper, 2017). The video features were particularly important for supporting teachers in seeing real examples of what scientific argumentation (a focus of the curriculum materials) looks like in the classroom—helping teachers develop knowledge related to argumentation as a science practice, as well as images of the possible vis-à-vis the vision of the NGSS.

Thus, educative curriculum materials can include a plethora of forms of support. What assumptions and principles can guide the design of these educative features? Recently, we reiterated two key assumptions for the design of educative curriculum materials (Davis et al., in press). The first, based on previous work on educative curriculum materials (e.g., Ball & Cohen, 1996; Hill & Charalambous, 2012; Remillard, 2005), stated that curriculum developers should purposefully *support different domains of teacher knowledge and practice* (i.e., subject matter knowledge, pedagogical content knowledge, and teaching practices for supporting 3D science learning). The second assumption was that educative curriculum materials should *make clear the rationales underlying instructional recommendations* (Davis & Krajcik, 2005). Including rationales is crucial for the development of knowledge that teachers can apply across contexts.

In the same paper, we presented a set of design principles (Davis et al., in press). The design principles grew directly out of our empirical work with teachers and students. In brief, the domain-general design principles suggested that educative features

> should (a) suggest adaptations of lessons that would take different amounts of time and meet a range of students' needs, (b) be situated and grounded in teachers' practice, (c) take multiple forms, and (d) work together to meet a range of teacher needs (Davis et al., in press, p. 28).

For example, in our research, we found that teachers effectively used rubrics illustrating key ideas about science practices, along with sample student work and sample teacher comments; these are examples of educative features that were situated in teachers' daily practice and could work synergistically to meet teachers' needs. Similarly, we found strong uptake of language and teaching practices from educative narratives describing how teachers adapted lesson plans to meet their students' needs.

The science-specific design principles went on to suggest that educative features in science curriculum materials should support explanation-construction and argumentation, as well as "entry-level" scientific practices (Davis et al., in press). We argued that prediction could serve as an "entry level" science practice in that it requires the kinds of justification of argumentation, yet feels lower stakes to both elementary students and teachers, and links to teaching practices teachers may already employ in their language arts instruction. We saw teachers using the educative features when they asked students to justify their predictions in ways that supported movement toward argumentation.

An NGSS-supportive educative feature, then, might take the form of a narrative describing how a fourth-grade teacher enacts a lesson that is part of an NGSS-aligned kit-based curriculum focused on a question about the role of light in vision. The narrative might make visible the teacher's understanding of elements of the NGSS vision (e.g., it might highlight the phenomenon of the reflection of light and describe how the teacher thought about the role of the crosscutting concept of cause and effect in the context of the lesson), and it might describe her decision-making around the supports she put in place for engaging her students in model-revision, based on their previous experiences and where she aimed to get with them by the end of the year. Related educative features might include rubrics with sample student models, with sample suggestions for revisions, and suggestion boxes for modifications to the lesson that might take less time (with caveats about "must include" portions of the lesson and rationales for their inclusion).

What are the challenges and opportunities?

Davis and Krajcik (2005) nominated several tensions in designing educative curriculum materials, and these tensions have not yet been fully resolved. First, educative curriculum materials must balance suggesting research-based instructional moves and being open to teacher modification. A second tension involves designing curriculum materials to be educative for a range of teachers. For example, given the diversity of student populations in US classrooms, educative curriculum materials need to support teachers in effectively reaching *all* students, and given the typical rates of teacher turnover, educative curriculum materials need to support beginning teachers. A third worry is about length – we can design any number of educative features for teachers, but teachers are unlikely to read a set of curriculum materials resembling the Oxford English Dictionary in their heft. Another challenge involves the design process itself. We developed a design process that grounds educative features in empirical findings (e.g., classroom observations, student work) and theoretical understandings (Davis et al., 2014). Curriculum developers, however, may not have the time or capacity to engage in this work without extensive research funding. Finally, educative curriculum materials cannot be treated as a panacea (Collopy, 2003). They should be used in conjunction with effective professional learning opportunities.

Technology has the potential to make educative curriculum materials more effective (e.g., Loper et al., 2017; Marco-Bujosa et al., 2017). Such materials might be able to adapt to teachers' expertise (Krajcik & Delen, 2017). Developing models to make educative curriculum materials more easily accessible to and customizable by teachers, perhaps through open source mechanisms, also presents an important opportunity—particularly as doing so would help to address some of the tensions described above.

These and other innovative approaches bear further attention as we continue to improve the ways in which we support teacher learning in moving toward the vision of the NGSS.

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