OpenSciEd

May 2021

Introduction

OpenSciEd instructional materials from kindergarten through high school are thoughtfully constructed with multiple familiar considerations and constraints in mind, such as standards, scope and sequence, an instructional model, and pacing. Yet, these elements are not enough. Instructional materials must convey a classroom vision that is inclusive of all learners and creates an image of how students will engage with the content, what type of discourse students will engage in, and a sense of what a teacher needs to make that vision come alive.

As an organization, OpenSciEd is committed to acknowledging and taking on inequities in education. As science educators, we endeavor to develop science instructional materials that provide equitable learning opportunities for historically disenfranchised students. OpenSciEd's beliefs about science learning and vision of the classroom are embodied in our design specifications. These sixteen specifications describe what we want science learning to look like for every student, and therefore guide our materials development process and implementation support. The topics addressed range from equitable science instruction and the centrality of asking questions, to meeting practical needs and constraints of a classroom. These specifications are based on *A Framework for K-12 Science Education* and the resulting Next Generation Science Standards, including the emphasis on three-dimensional learning.

On the following pages are short descriptions of each specification; the complete specifications can be found on our website www.openscied.org/design-specifications/.

1–Instructional Model

Instructional materials provide a coherent path anchored in students' own experiences and questions to build disciplinary core ideas and crosscutting concepts through an iterative process of questioning, investigating, modeling, and constructing explanations. Students experience learning as meaningful (making sense of ideas rather than just reproducing them), cumulative (learning challenges require them to use and build on what they figured out in previous lessons), and progressive (the class improves explanations or solutions over time by iteratively assessing them, elaborating on them, and holding them up to critique and evidence).

2–Equitable Science Instruction for All Students

In developing instructional materials today, we must recognize the vast range of student diversity in today's classrooms and honor the cultural and linguistic assets that students bring, while acknowledging the deep injustices in society. Therefore, instructional materials need to build on the guidelines in *A Framework for K-12 Science Education* and the *Next Generation Science Standards* (*NGSS*) to support learners who come from non-dominant communities or are underrepresented in STEM classes, college majors, and careers. Instructional materials guide teachers in implementing equitable science instruction for all students, and are flexible enough to be adapted to fit teachers' and students' local circumstances. The practices described in the equity design specifications are central to science teaching and learning everywhere and for all students; they are not add-on strategies that only need to be deployed in the presence of students from historically underserved communities. By design, these materials relate to the interests, identities, and experiences of students and the goals and needs of their communities. The instructional materials support equitable participation in science and engineering practices in ways that are culturally sustaining, leverage students' full linguistic repertoires (multiple languages and registers), and value and promote multi-modal performances beyond written or spoken forms of expression.

3–Classroom Culture

In this chapter we unpack a key aspect of achieving equitable instruction and the resultant learning by examining the role of classroom culture. Research indicates that a focus on equity aims demands attention to *culture*, defined as "everyday classroom practices that promote particular meanings of 'science'" as well as the normative identities developed within that classroom culture. For this document, we are using the definition of a normative identity as the "culturally produced meanings of 'science person' and the accessibility of those meanings" (Carlone, et al, 2011). Without intentional attention to establishing a culture that explicitly names class norms and practices that honor student voice and support identity development, classroom practices function as gatekeepers that prohibit equitable access to high-quality science education.

4– Supporting Multilingual Learners

To acknowledge the diversity of English Learners and value the cultural and linguistic contributions they bring to a classroom and community, the term "multilingual learners" (MLs) will be used throughout OpenSciEd materials. Instructional materials should be designed based on best practices defined in the WIDA English Language Development Standards Framework. In particular, this framework emphasizes the goal of increasing equity for multilingual learners by providing common and visible language expectations in relation to grade-level academic content. Science instruction for most MLs is still conducted in English thus, students must be provided equitable access to academic content in a language that they are still acquiring. To encourage teachers to sustain both science content and language acquisition, instructional materials provide teachers with contextualized scaffolding so that they can amplify language to support science learning, help students develop metalinguistic awareness, and support their learning over time.

5–Assessment to Inform Teaching and Learning

OpenSciEd assessments are designed in tandem with instructional materials design so that the evidence gathered through assessment can inform teachers as they refine their instructional decisions in support of learning. When developing instructional materials it is critical that well-designed assessment opportunities are fully integrated and embedded into the learning experiences. The assessment strategies and tools should support teachers and students in gathering evidence of learning that informs decisions and promotes reflection. These tools and strategies may range from informal assessment conversations that occur during instruction to formative assessment opportunities such as embedded tasks with rubrics that support the interpretation and use of student ideas to inform instruction to summative assessments such as tests, projects, and portfolios. Curriculum-based assessments are not designed to mimic large-scale summative state-level tests, but rather the assessments included with instructional materials support teachers' and students' understanding of what they have learned and how they have made sense of phenomena.

6–Designing Educative Features

The goal of educative instructional materials is to efficiently support teacher learning as well as student learning. Educative features are the elements added to the base materials that are explicitly intended to promote teacher learning. For elementary teachers these features need to support the development of subject matter knowledge, pedagogical content knowledge, the confidence to use teaching strategies that support 3-dimensional learning experiences in which students are "figuring out" phenomena, and the integration of ELA, mathematics, and social studies. In addition, it is critical that the teacher materials are explicit about the rationale for each feature included to support teachers' decision making about how they will use the instructional materials. OpenSciEd's educative features are designed to support the wide range of teachers who use the instructional materials and to help teachers find the support they need, when they need it.

7–Asking Questions and Defining Problems

A basic practice of the scientist is "formulating empirically answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered". OpenSciEd materials are based on the premise that students conduct themselves as scientists and engineers while learning science. Students' questions about phenomena or engineering problems drive their learning activities forward, and their curiosities and interests motivate learning through the cycles of investigation, analysis, modeling, and argumentation. Instructional materials emphasize that science and engineering involve unresolved questions or problems, and support students in navigating this uncertainty.

8–Planning and Carrying Out Investigations

Instructional materials for elementary settings need to offer opportunities for student investigations that are developmentally appropriate. That means, for example, that K-2 students are planning simple investigations such as planting seeds in different conditions and 3-5 students are learning to control variables and pool data with their classmates to draw conclusions. The vision of OpenSciEd is to

OpenSciEd

promote scientific investigation that is part of a complex constellation of knowledge-building practices. What counts as an “investigation” is broad and emphasizes the need to generate evidence so that students engage with the data. Equally important, a hands-on activity includes talk or discussion around planning it, carrying it out, and interpreting and communicating what happened.

9–Developing and Using Models, Constructing Explanations, and Designing Solutions

In OpenSciEd materials, models are positioned as intellectual tools used to reason with and develop explanations for phenomena. This intellectual work happens through negotiation between students as they decide how to construct and revise models of phenomena. Students have multiple opportunities to return to their ideas to revise, discard, add to, or expand them as they gain new evidence from investigations and other sources. Modeling and explanation are collaborative endeavors that advance the understanding of the members of the classroom community, which means that the work of the community is made public, and students have opportunities to share, critique and build on one another’s ideas. Across the elementary grades, students engage in this practice by developing and using models as literal depictions of the world building towards increasingly symbolic representations of their ideas. Engagement in this practice at the K-2 and 3-5 levels supports students in developing the understanding that our ideas about the natural world can be represented in ways that can be collaboratively visualized, shared, compared, and refined.

10–Analyzing and Interpreting Data and Using Mathematical and Computational Thinking

OpenSciEd materials provide students with opportunities to explore natural events or think about solutions to a problem, where they are not just interested in describing what is happening. Students are also interested in how much, how fast, or how frequently something has happened, and how it may happen in the future or in a different circumstance. These practices offer specialized ways for describing the observations made during investigations precisely and systematically. At the elementary level working with data also helps students gain an appreciation that recording data helps them keep track of phenomena and ideas over time and also helps others know a little about what they were thinking. In grades K-2, analyzing and interpreting data is about recording and sharing observations and using those observations to describe patterns and relationships in the natural world. In grades 3-5, students develop representations of data in multiple ways to reveal patterns and they develop, explore, and conduct analyses on observations that have been recorded with varying degrees of precision so they can develop an appreciation for precision.

11–Arguing from Evidence and Obtaining, Evaluating, and Communicating Information

Students learn when engaged in meaningful forms of argumentation and communication. Argumentation engages students in opportunities to construct and defend their claims using evidence, as well as critique arguments presented by others. OpenSciEd materials provide structured opportunities for students to participate in arguing and communicating about elements of their work for the authentic purpose of explaining a phenomenon or designing a solution, at increasing levels of sophistication over time. OpenSciEd materials, along with classroom culture, promote the shared goal of consensus, achieved through collective norms practices that promote scientific argumentation. It is important to note that the CCSS-ELA does not use the term "argument" for the elementary grades. Rather these standards make a connection to science by saying that "students make claims in the form of statements or conclusions that answer questions or address problems. Using data in a scientifically acceptable form, students marshal evidence and draw on their understanding of scientific concepts to argue in support of their claims. Although young children are not able to produce fully developed logical arguments, they develop a variety of methods to extend and elaborate their work by providing examples, offering reasons for their assertions, and explaining cause and effect. These kinds of expository structures are steps on the road to argument. In grades K–5, the term "opinion" is used to refer to this developing form of argument."

12–Crosscutting Concepts

Crosscutting concepts are ways of understanding scientific concepts as they relate to real-world phenomena and are central to robust and applicable science understanding. In OpenSciEd materials, crosscutting concepts continually develop as students explore, explain, and make sense of phenomena at increasing levels of sophistication within units, across units, and across grades. Units are designed so that students experience the continual integration of crosscutting concepts in ways that they recognize are relevant and useful to the context and activities of the unit. Students learn to use consistent language of crosscutting concepts when discussing phenomena and engaging in science practices. At the elementary level, the explicit development and use of these crosscutting concepts provides the foundation for their increasingly intentional and sophisticated use as familiar tools for sensemaking and problem-solving about natural phenomena as well as offering opportunities to leverage connections to student learning in ELA and Math.

13–Classroom Routines

Classroom routines are structures that students engage in repeatedly over the course of a year and across multiple years. OpenSciEd instructional materials include structured routines with explicit goals to serve as scaffolds for students to learn sophisticated scientific and engineering practices, and to establish and maintain an engaging, productive, and equitable classroom culture through norms and expectations about behavior and social interaction. Routines help draw out student questions and identification of problems and use them to guide the ongoing science work of the class, support students in tracking progress toward the unit's learning goal as well as the current explanations, models, or designs, and help students develop gapless explanations and discuss how to move from one lesson to the next. Teachers are guided in developing and maintaining classroom norms to support student engagement in the science and engineering practices through productive talk.

OpenSciEd

14–Integration of English Language Arts and Mathematics

OpenSciEd materials integrate English Language Arts (ELA) and mathematics into science Instructional materials to build a strong base of knowledge through content-rich text-and to reinforce science learning through literacy and mathematics connections. This is accomplished through the careful alignment of the science standards and the deep integration of practices from mathematics and ELA that can be used to strengthen the learning and doing of science and engineering. This integration should be driven by what is needed to learn the science and be intentional, not an afterthought.

15–Meeting Practical Needs and Constraints of Public Education

OpenSciEd materials will transform educational practices and improve outcomes for students because it recognizes the importance of practicality. OpenSciEd will incorporate attributes known to support transformation and improvement that are practically possible and realistic for teachers to implement. Practicality is contextual. The thresholds for what makes a program too challenging or infeasible depend on the social capital and material resources that are available in a particular setting. Therefore, the materials will provide flexibility to help educators, schools, and districts to make informed decisions on how they customize materials for their contexts.

16–Guidance on Modifying Instructional Units

OpenSciEd instructional materials are an Open Educational Resource with the explicit goal of supporting the adaptation and customization of the program for different goals and circumstances. Teacher materials include guidance on possible modification to the units, the implications of potential changes, and the rationale behind the sequence and design of activities that will allow others to adapt, modify, and customize the materials in a way that still achieves the goals of the program. Teacher materials also provide educators with information about pacing, including when activities can be compressed or extended. Information on which learning goals are emphasized at key parts of the materials will allow educators to make decisions about supplementing materials or customizing those materials for a particular student audience.