DESIGN SPECFCIATIONS OVERVIEW

Many considerations must be taken into account in designing instructional materials to create a product that lives up to the expectations of students, teachers, schools, and districts. There are the obvious and necessary elements that must be addressed, such as standards, scope and sequence, instructional model, and pacing. OpenSciEd instructional materials are thoughtfully constructed with all of these considerations and constraints in mind. Yet, these elements are not enough. Instructional Materials must have a classroom vision, 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 standards come alive.

OpenSciEd's beliefs about a science learning and vision of the classroom are embodied in our Design Specifications. These fourteen 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 that integrates science and engineering practices, crosscutting concepts, and disciplinary core ideas. On the following pages are short descriptions of each specification; more detailed information can be found at www.openscied.org.

Instructional Model

OpenSciEd materials are 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 making sense of ideas from their own perspectives. In order to do this, student learning is motivated by making sense of phenomena which lead to iterative cycles of investigating phenomena, refining questions, improving explanations and models with new evidence, and further questioning. Students are positioned as collaborators who work as a community to figure something out about the natural or designed world. Units are organized into a coherent storyline and fit into the scope and sequence with explicit connections.

Equitable Science Instruction for All Students

OpenSciEd materials guide teachers in implementing equitable science instruction for all students, with particular attention to student groups who have historically been underserved in science. Equitable instructional practices are central to the material's design, not add-on strategies that need to be deployed in the presence of certain students. Instructional materials are flexible enough to be adapted to fit teachers' and students' local contexts. 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.

Assessment to Inform Teaching and Learning

OpenSciEd assessments are designed in tandem with the instructional materials so that evidence gathered through assessment is a seamless element of instruction. Well-designed assessment opportunities support evidence gathering for a wide range of purposes, including formative tasks that occur during instruction, embedded tasks with rubrics that support the interpretation and use of student ideas to inform instruction, and summative tasks. Assessments involve students in analyzing their own and their peers' ideas and considering how to use those ideas as they move forward in making sense of phenomena. Assessment opportunities anticipate the wide range of backgrounds and experiences that students bring to the science classroom, and assessment tasks are dexterous enough to capture students' initial ideas at the start of the unit and how these ideas develop as students integrate information and evidence from unit activities.

Designing Educative Features

Educative features are the elements of the teacher guidance materials that promote teacher learning and support the wide range of teachers who use the materials. OpenSciEd educative features help teachers find the support they need, when they need it. Teachers are guided in teaching toward a Next Generation Science vision through the use of instructional materials that are effective and efficient, and that support teachers and students to spend more time engaged in teaching and learning. The educative features a teacher accesses their first year using the materials will be different from those in future years when the material is more familiar.

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. The instructional materials explicitly support asking *wonderment questions* (that draw out the awe and wonder of a phenomenon), *classroom discourse questions* (that students ask of each other to support productive disciplinary discussions), *investigation questions* (that guide the design of a specific investigation), *procedural or design questions* (about measurement or methods), and *epistemic questions* (about the reasons for pursuing specific questions, what we already know and don't know, and the steps we need to take next). Instructional materials emphasize that science and engineering involve unresolved questions or problems, and support students in navigating this uncertainty.

Planning and Carrying Out Investigations

The vision of OpenSciEd is to promote scientific investigations as part of a constellation of knowledge-building practices. Planning an authentic investigation involves identifying and revising questions with a specific purpose in the same manner as a scientist or engineer. In order to count as an investigation, a proposed activity needs to generate evidence that students can engage with. Equally important is that a "hands-on activity" includes discussion around planning an investigation, carrying it out, and interpreting and communicating what happened. OpenSciEd instructional materials support students in designing and carrying out investigations that allow for a deeper understanding of the science being investigated, and support teachers to navigate learning with student-centered investigations. Investigations have an authentic and explicit purpose for student sense-making, and instructional materials highlight connections between the other practices and crosscutting concepts to the practice of planning and carrying out investigations.

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, whether in small groups or in a whole group setting, and important learning happens in the discussions students have while deciding how to construct or revise models, or how to explain a phenomenon or design a solution. 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.

Analyzing and Interpreting Data and Using Mathematical and Computational Thinking

OpenSciEd materials provide students with ample opportunities to use data analysis and computational thinking as they develop explanations and design solutions. Often when exploring a natural event we are interested in how much, how fast, or how frequently something has happened, and how it may happen in the future. Both the practices of "Analyzing and interpreting data" and "Using mathematics and computational thinking" offer specialized ways for describing the observations made during investigations. Instructional materials focus on students' ability to contextualize data, mathematical models, and simulations, and help students develop their statistical, mathematical, and computational toolkits.

Arguing from Evidence and Obtaining, Evaluating, and Communicating Information

OpenSciEd materials create opportunities for students' home experiences and ways of knowing to be a productive part of the classroom sense-making by showing the ways argumentation and communication vary across individuals, classrooms, out of school contexts, and disciplines. Students learn more when engaged in meaningful forms of argumentation and communication; thus the instructional 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. Activities attend to the linguistic demands inherent in arguing and communicating across productive (writing and speaking) and receptive (reading and listening) language functions.

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.

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.

Integration of English Language Arts and Mathematics

OpenSciEd units integrate with English Language Arts through the literacy practices of reading, writing, and communication, and with mathematics, to develop and reinforce important science ideas and practices. Instructional materials support students in strengthening their literacy and mathematics practices and thinking, and in demonstrating the importance of these practices for science.

Meeting Practical Needs and Constraints of Public Education

To bring about real and lasting transformation of science instruction, OpenSciEd materials are designed to be practical and realistic for educators to implement. Instructional materials help teachers plan and implement coherent three-dimensional learning experiences for all students in every activity, and include meaningful *optional* learning opportunities after specific points in a unit to motivate students to think, talk, and explore outside of school. Teachers are guided in using student work for grades while also providing meaningful feedback to students about their learning. Computational technology supports three-dimensional science learning, within school constraints. Students are provided with the greatest possible opportunity to engage in scientific and engineering practices with appropriate tools and techniques, within school constraints.

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.