

DEPT. OF EDUCATION AND
EARLY DEVELOPMENT



Teacher Primer for the Science Standards for Alaska

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Introduction

New adventures are ahead in science teaching! Truly, it might be a little overwhelming to recognize how much the expectations seem to have changed as science education in Alaska makes its shift to these new standards. Honestly, though, science teachers could become the heroes. Science can engage reluctant readers, an important step to meeting Alaska’s Education Challenge* that administrators and school boards are talking about. Instilling genuine science and engineering skills contributes to career and technical education goals, especially in Alaska where there is a huge need for science and engineering skills in the natural resources and medical fields as well as in building and maintaining infrastructure. Emphasizing the broad ideas, the concepts that frequently emerge throughout the fields of science and elsewhere, can help students grow into strong readers of non-fiction. Making connections right out of the gate using phenomena that students are exposed to outside of school will really make learning and teaching more interesting. Let the investigating and problem solving begin!

One of the primary motivators for this huge revamp is to promote equity, letting everyone experience the “good stuff.” With the reduction in the number of topics to be studied in each grade level, teachers won’t have to cram so much into one school year. No more “mile wide, inch deep” curriculum. It is true that students are going to be asked to “show what they know” in new ways; some students will truly thrive with the new performance expectations. For example, students who are overwhelmed by written tests and some of our English language learners may have an easier time using a model they made to support their explanations. By having more engagement through discussions and arguing from evidence, misconceptions are uncovered, and genuine knowledge can be shared and celebrated.

Alaskans have a reputation of being “doers;” we live in a place that seems to make us want to challenge ourselves, a land of independent thinkers and do-it-yourselfers. This truly is a transition our students and ourselves are made for.

Stepping up to new standards will have big payoffs. And it won’t all happen at once. Simply trying one lesson or one unit and sharing experiences with a colleague will forge a trail. This primer is intended to be an overview of some of the changes with a nod to the realities of being a teacher somewhere in Alaska, from remote villages to small towns to our urban hubs.

Three-Dimensional Learning

Three-Dimensional Learning (and teaching) figures strongly in the new Science Standards for Alaska. No, you won’t need special glasses for this. But it is true that all three dimensions will need to be embedded in all lessons, units, and district-wide curricula. These are the ingredients that make science education the important and engaging element that it is in a student’s school experience. The three are: Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs), and Crosscutting Concepts (CCCs).

The three dimensions appear in colored rectangles, called foundation boxes, below each standard. They explain what practices will be demonstrated when a student is completing each assessment task, what knowledge should have been acquired from their experiences prior, and what broad science concepts come into play while preparing for and doing the task.

The reason this 3D approach is so critical to effective teaching and learning is that science is a set of skills as well as a body of knowledge. The student needs to be the explorer, not just a follower. During that exploration, real science practices are developed *en route* to the acquisition of knowledge, which will be demonstrated in the performance expectation.

Phenomena

Phenomena are central to the new standards. They are real-world examples of science in action that engage students in complex problems. To get a good sense of what is meant by phenomena, take a walk, a road trip, or a boat ride with a five-year old. The questions that a child poses whenever something interesting crosses their path are connected to phenomena. If something can be investigated using science and that investigation produces evidence, it is a great place to start a unit or lesson. If it relates to a problem that can be solved using engineering, it will also generate the kind of inquiry that gathers evidence and provides a path toward understanding of some science principle or knowledge.

Importantly, phenomena don't have to be anything amazing. They have to provide something worth wondering about for students and something you can't just look up on the Internet without having to analyze and determine the truth. Some phenomena are broad questions, and will require several explorations to gather evidence to support an explanation. Each is called an anchor phenomenon. Along the way lesson-size phenomena can be acknowledged and investigated.

Good sources of Alaska-centered phenomena are *Village Science* by Alan Dick, *Alaska Science Nuggets* by Ned Rozell, UAF Geophysical Institute, NOAA Arctic Program, and media such as public radio and newspapers. Other catalogs will likely be posted here as more schools actively teach to the new standards. Marine mammal diseases, caribou migrations, the Anchorage and Aleutian earthquakes, the frozen debris lobes along the Dalton highway, retreating sea ice affecting color of the tundra, changing fish runs, and, of course, the Aurora, are all distinctly Alaskan phenomena.

More universal phenomena to be explored could be the contrast between atmospheres in two different planets, ocean temperatures changing over time, how electric cars work, whether recycling really saves energy and resources. Even something like a teenager dropping her phone breaking the screen even though it was in a case can be studied as a phenomenon. That could even lead to a new idea for an invention and call in engineering skills as well.

With so many rich resources available online from credible resources, students can study phenomena they could never experiment with in a lab at school.

Examples are IRIS for patterns of global seismicity, USGS Alaska Science Center for a wide range of earth science study including the debris lobes mentioned above, even the Alaska ferry Columbia which took transects of ocean conditions every week,

Phenomena stimulate conversation between students, leading them to the need to explain and argue from evidence that a certain general statement can be made, that predictions of what would happen in another occurrence would be valid.

Storylines

Science Standards are shifting away from promoting the memorization of facts to deeper learning. Educators realize that a key to that is the creation of more connections among concepts and ideas presented and explored over time. It's just how our brains work; we need a place to put new material. So now, the term storyline is commonly used in conversations about educational practices that contribute to shifts to new science standards.

Contained in the standards at the start of each topic section is a "content storyline" that sets the parameters and delineates relationships to be explored within that topic or grade level. K-5 storyline describes what will be addressed in the entire grade. Grades 6-12 storylines are distinct within each discipline.

However, since the shift also includes using student-driven investigation of phenomena, the storyline needs to wrap around a phenomenon, referred to as an anchor phenomenon if it will be explored for a whole unit. Teachers, then, will want to develop their own conceptual, student-driven storylines built from the phenomena that students want to explore. This strategy creates exciting opportunities that truly motivate students to use their science and engineering practices as they ask questions and try to find answers that they can explain using science knowledge. In a classroom setting, that is contagious.

You might feel like you are a little adrift if the storyline is something that hasn't even been created, and there is no textbook to guide you. But you are lucky! Teachers have been contributing to websites to assemble some good ideas that have worked in their own classrooms, so there is a wealth of resources available online and you are invited to share yours on some of them.

Alaskan storylines could include why the eagles gather on the Chilkat River every fall, exploring which fish traps or halibut hooks worked best, what happened to the ten thousand smokes of Katmai National Park, how can solar power be tapped when it is so dark in the winter, what engineering practices were used in building the Alaska Highway back in the 1940's. You might be inspired to come up with a new storyline idea just by reading a newspaper, watching a television program, or conversing with friends or family.

Arguing from Evidence

One of the greatest benefits that can come from faithful effort to incorporate the foundations of these standards in student learning is the development of an ability to explain and argue from evidence. Students will learn to analyze the data they produce, determine if generalities can be drawn from it, then construct an argument using that evidence. The arguments will be subject to peer review and students will be called upon to defend the basis of their claim in detail. Arguing is not conflict; it is explaining through logical reasoning associated with real results.

The comment, all too common, “I’m not a scientist, but...” may sometimes represent an unwillingness of a speaker to dig deeper, question what is being stated, insist that the process of investigation that led to the data be revealed. Anyone can learn to think like a scientist. With the widespread transmission of information available to us now, it has never been more important to be able to sort through what is true and how we know it. Raising the bar through education so that students know they will be called upon to defend their claims with evidence is a worthy pursuit.

Students need to be clear on what constitutes evidence supporting their claim that explains a phenomenon. The nature of science is such that evidence has to be observable, not a hunch or a hope. Forever humans have been making survival decisions based on knowing about their natural world. In Alaska today people pay close attention to evidence about weather changes, caribou movement, the condition of a forest as a source of firewood.

One way to think about this practice is that it requires establishment of a claim which answers a question about the phenomenon, evidence which comes from the observations made, and reasoning, which uses information a student knows or learned through another experience and it supports the claim.

Developing and Using Models

It is no coincidence that models figure in two of the three dimensions. They are a way our mind makes sense of new ideas, so certain facts are “stored” that way, and they also provide a means to organize evidence arising in an investigation as well as a way to communicate ideas to others, to test and evaluate the ideas by considering if there are factors overlooked, erroneous assumptions, or even parallels or conflicts with other proposed system models or previously accepted ones.

One reason that students are encouraged to develop and use models is that brain research shows that the processing of visual stimuli taps into more places in the brain, building connections. The use of models as a base in delivering an explanation can reveal a student’s misconception or their solid understanding.

Models don't have to be anything elaborate. As a representation of a relationship, spatial or otherwise, it can be a drawing, an interactive computer graphic, a skit, something that is built from objects. Simple classroom materials often serve the purpose well. Even just a math formula could be used as a model in some cases if the role the variables and numbers play in the actual phenomena or relationship are explained.

Of course, the level of complexity and specificity of the models progresses through the grade levels; the level of understanding in distinguishing between a model and the real thing evolves. Continuous improvement in developing and revising models that depict the situation accurately is expected as well.

Performance Expectations

The performance expectations are the statements that are listed under each grade level on those all white pages of the Science Standards for Alaska. As standards organized in the fashion that some teachers have learned as "Understanding by Design" or "backward design," these are the tasks by which teachers will assess what students know and can do. Each is a prompt to guide the teacher toward a target, giving a view ahead and suggesting learning experiences leading up to it.

These assessments are truly the "live show" now, with most of the PEs requiring the demonstration of a Science or Engineering Practice (SEP), e.g., using a model to explain or describe something, analyzing data, arguing from evidence. These are things students should be able to do by the end of the grade. However they could reasonably be called upon to demonstrate the performance expectation at the end of a sequence of explorations around phenomena related to that topic.

There are three to six PEs for each topic in the standards. This doesn't mean a teacher doesn't use other means of assessing along the way or even at the end, but the PEs are considered a definitive way to "know that they know." And in the process of purposefully completing that assessment task, they are doing science, or engineering, like real scientists and engineers.

For example, in the PE coded MS-PS1-4, a middle school student learning physical science is asked to "Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed." A student could draw and label a before and after picture of butter placed in a hot frying pan or hot seal oil left out in a metal can, put tiny objects in a jar to model particles, make a poster of why it's good to cover something you put in a microwave oven, why we change the oil in the truck after it has run for awhile, what happens to a chocolate bar if left next to a window on a warm day.

Listed under some PEs in the standards are either a "clarification statement," an "assessment boundary," or both. The clarification statements elaborate on what should be incorporated into

the learning leading up to the performance. Sometimes they include an Alaskan context, or phenomenon, that might be helpful in connecting with students. The assessment boundaries explain what does or does not have to be known at this point in a learning progression on that topic. It doesn't mean you can't teach beyond this depth, but that is not included in the assessment at this grade level.

Science and Engineering Practices

The Science Standards for Alaska focus heavily on students engaging in the practices of science and engineering, to assist them in figuring out the natural world and solving problems.

The Science and Engineering Practices include:

Asking questions and defining problems

Students ask questions and define problems that require solutions as they investigate phenomena in the world around them.

Developing and using models

Students develop and use models to discuss their ideas. Models can include drawings, 3-dimensional representations, and simulations, etc.

Planning and carrying out investigations

Students plan investigations that isolate variables, and collect meaningful data.

Analyzing and interpreting data

Students analyze data from personal investigations or from other data sets available from sources such as NOAA, NASA, US Census Bureau, etc.

Using mathematics and computational thinking

Students use mathematics to assist in analyzing data, and determining possible relationships.

Constructing explanations and designing solutions

Constructing explanations to describe data and any conclusions along with supporting evidence.

Engaging in argument from evidence

Use evidence from investigations, data analysis, etc. to support claims made regarding a particular topic.

Obtaining, evaluating, and communicating information

Gather evidence from a variety of sources, evaluate the information, and communicate findings.

Disciplinary Core Ideas

Disciplinary Core Ideas are the fundamental ideas necessary for understanding a given science discipline. The core ideas all have broad importance within or across science or engineering disciplines, provide a key tool for understanding or investigating complex ideas and solving problems, relate to societal or personal concerns, and can be taught over multiple grade levels at progressive levels of depth and complexity.

Disciplinary ideas are grouped in four domains: physical science; life science; earth and space science; and engineering, technology and applications of science.

Physical Science:

Students learn about the physical and chemical subprocesses that regulate systems. This includes the study of matter and its interactions, chemistry, nuclear processes, motion and stability, forces, energy, waves, radiation, and the application of technology.

Life Science:

Students learn about the patterns, processes, and relationships of living organisms. This includes a study of structure and function, organismal growth, biological organization, interactions, cycling of energy and matter, ecosystems, heredity, and evolution.

Earth and Space Science:

Students investigate the processes that operate on the Earth and address its place in the solar system and galaxy. This includes studying the universe, solar system, Earth, geology, hydrology, weather, and human impacts.

Engineering, Technology, and Application of Science:

Students focus on developing an understanding of engineering practices to help inform the acquisition and application of scientific knowledge. This includes defining and delimiting problems, developing solutions, and refining solutions.

Crosscutting Concepts

Crosscutting concepts (CCCs) are essential tools for teaching and learning science that help students understand the natural world by making sense of phenomena across scientific disciplines. CCCs provide a scaffold upon which teachers and students can organize the cognitive structures for unifying the science disciplines.

The Crosscutting Concepts include:

Patterns

Observed patterns of forms and events guide organization and classification. Patterns prompt questions about the factors that influence cause and effect relationships. Patterns are useful as evidence to support explanations and arguments.

Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted and complex. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, Proportion, and Quantity

In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and System Models

Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Energy and Matter

Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the system's possibilities and limitations.

Structure and Function

An object's structure and shape determine many of its properties and functions. The structures, shapes, and substructures of living organisms determine how the organism functions to meet its needs within an environment.

Stability and Change

For natural and built systems alike, conditions of stability and rates of change provide the focus for understanding how the system operates and the causes of changes in systems.

Bundling

Your first thought when you see the word bundling might be that you should go get another load of firewood. And it might cross your mind that it's easier to carry the kindling in when all the sticks line up nicely. The bundling of standards is like that; the end points, or performance expectations, are coordinated to form the end of a unit or teaching sequence. There are many reasons for a district or school or individual teacher to create their own bundle and not necessarily follow the grouping as presented in the Science Standards for Alaska. It is important, however, to make it clear to all why the bundle is established as it is. In other words, what is the rationale for relating those PEs to one another?

There could be a phenomenon that lends itself to PEs from more than one field of discipline. The debris lobes that are sliding down onto the Dalton Highway might be an example. Understanding of the gravity and phase changes that are creating instability could be part of the story, and that includes DCI's from the Physical Science realm, but knowing how different

substrates behave in the presence of moisture and why the change is occurring in the first place could be represented in the Earth Science section.

Bundling across grade levels may be necessary in smaller schools for efficiency of instruction or to share equipment and materials. There could be a community project that involves the whole school, which may provide a great venue for teaching science, such as building a “rain garden” or creating a recycling center. Clearly it is most effective when the DCIs, and therefore PEs, are considered in a “suite” and not in isolation.

The facilitators of the new regimen of science standards being embraced across the country have created some suggestions of bundles as well as criteria for educators to develop their own combinations.

Cultural Connections

Educational equity is at the heart of the new standards. The shifts that Alaska science education is taking will help reach more students, including rural native students who may have felt left out in classrooms that were textbook- and lecture-rich and moved quickly through many concepts that seemed distant from the daily life they were living.

Now that the learning will be phenomenon-driven, the starting point will be a connection with experiences students have or observances of nature that they wonder about. There are plenty of opportunities to apply the disciplinary core ideas to the lifestyle that is familiar to students in all settings in Alaska. Asking the students for ideas of what to study will help them take responsibility for their education and honors what they know.

In the Alaska Standards for Culturally Responsive Schools it is stated that *“Culturally-knowledgeable students are able to engage effectively in learning activities that are based on traditional ways of knowing and learning.”* In this section of the guide, acknowledgement of Elders as culture-bearers and educators and gathering oral and written history are explicitly encouraged. *“Finding solutions to everyday problems”* and *“enhancing life skills”* are also applicable to science education.

Appearing in another section of the guide is, *“Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them.”* This is a perfect fusion with the idea of using natural phenomena to drive science instruction. Culturally responsive educators themselves are directed with the statement to *“...incorporate local ways of knowing and teaching in their work... use the local environment and community resources on a regular basis to link what they are teaching to the everyday lives of the students...provide the challenges necessary for them to achieve...”* Science for all is paramount.

Schools in Alaska include students from a diversity of cultures. The same motivation to be inclusive in choosing phenomena exists in towns and cities as well. The idea of changing the

way science and engineering are taught in Alaska is to open doors for all students. Creating opportunities during research to recognize the contributions of scientists and engineers from a variety of nations and backgrounds will serve well to help students see themselves as being able to follow in their footsteps. Research is showing us this is no small thing. A student may not call out, “Hey! She looks like me!” But she may be feeling it deeply, especially as student confidence grows through meaningful 3D teaching.

The Standards are Not the Curriculum

There is no question that the new Science Standards for Alaska are a comprehensive effort and a huge amount of detail is incorporated. But they are a guide, not a curriculum. The former Alaska standards were not a curriculum either but provided the substance to develop one. If a teacher new to teaching or new to these standards were to walk in and be directed to the Science Standards for Alaska, they would not really know where to start since the first thing they would see is the assessment. Then they would notice the foundation boxes. Still they would see no structure suggesting where they might start with a first unit for the year.

It is not necessary to start from scratch on a curriculum, but a group of informed and thoughtful people familiar with the Science Standards for Alaska should review the current one to see if it aligns. There may be a need to move some topics to a different grade or build in the “bundling.” The curriculum could even include storylines as teachers come up with them, perhaps providing a table that shows what DCI’s are included in each, which CCC and SEP will be built in, and which Performance Expectations apply.

Achieve is an independent, non-partisan, non-profit organization, who contributed to the standards that have led to the new Science Standards for Alaska. They offer a guide* to help Districts decide what materials truly are aligned to the standards upon which Science Standards for Alaska are based. Marketing is powerful and it is easy for publishers to distribute promotional materials to teachers, administrators, even parents. Acquiring what really will meet the goals of the standards takes some scrutiny as well as convening a group of thoughtful educators to decide what is right for their community and students.

Some districts already have a curriculum for science and engineering that references the new standards. The curriculum may designate certain amounts of time for each science discipline, and states the big ideas, essential questions, and useful vocabulary. Some may link phenomena or storylines, suggest community resources, and align ELA, math, CTE, or social studies standards.

Resource links

General Resources

- [Science Standards for Alaska](https://education.alaska.gov/standards/science) (https://education.alaska.gov/standards/science)
- [Alaska's Education Challenge](https://education.alaska.gov/akedchallenge) (https://education.alaska.gov/akedchallenge)
- [A Teacher's Perspective about the transition to new standards](https://www.youtube.com/watch?v=f479iHKYY_E) (https://www.youtube.com/watch?v=f479iHKYY_E)

Phenomena

- [Database of Everyday Science Phenomena](https://www.ngssphenomena.com/) (https://www.ngssphenomena.com/)

Storylines

- [Database of storylines for all grade levels](https://www.nextgenstorylines.org/what-are-storylines) (https://www.nextgenstorylines.org/what-are-storylines)
- [The Storyline Approach](https://stemforall2019.videohall.com/presentations/1624) (https://stemforall2019.videohall.com/presentations/1624)
- [Using Storylines in High School](https://sites.google.com/site/drnormanherr/presentations/ngss-chemistry-storylines---paradigms-for-teaching-and-learning-chemistry) (https://sites.google.com/site/drnormanherr/presentations/ngss-chemistry-storylines---paradigms-for-teaching-and-learning-chemistry)

Arguing from Evidence

- [Argumentation Toolkit from Lawrence Hall of Science](http://www.argumentationtoolkit.org/resources.html) (http://www.argumentationtoolkit.org/resources.html)
- [Progression Matrix for Engaging in Argument from Evidence](https://ngss.nsta.org/practices.aspx?id=7) (https://ngss.nsta.org/practices.aspx?id=7)
- [Bozeman Science: Claim, Evidence, Reasoning strategy](https://www.youtube.com/watch?v=5KKsLuRPsvU) (https://www.youtube.com/watch?v=5KKsLuRPsvU)

Developing and using models

- [Using Models Across Grade Levels](https://ngss.nsta.org/Practices.aspx?id=2) (https://ngss.nsta.org/Practices.aspx?id=2)
- [Developing and Using Models](https://www.youtube.com/watch?v=-Fdd0JMVmNA) (https://www.youtube.com/watch?v=-Fdd0JMVmNA)
- [Developing and Using Models of Electrical Interactions](https://www.youtube.com/watch?v=tXptM5HPm-Y) (https://www.youtube.com/watch?v=tXptM5HPm-Y)
- [Exploring our Fluid Earth](https://manoa.hawaii.edu/exploringourfluidearth/curriculum-alignment/ngss/sep/developing-and-using-models-0) (https://manoa.hawaii.edu/exploringourfluidearth/curriculum-alignment/ngss/sep/developing-and-using-models-0)

Performance Expectations

- [Bozeman Science](https://www.youtube.com/watch?v=1g9CUY1TBS8) (https://www.youtube.com/watch?v=1g9CUY1TBS8)
- [Houghton-Mifflin](https://www.youtube.com/watch?v=-AjQjOwr1zk) (https://www.youtube.com/watch?v=-AjQjOwr1zk)

Science and Engineering Practices

- [How Practices Change](https://www.youtube.com/watch?v=Jal6uAlZcsw) (https://www.youtube.com/watch?v=Jal6uAlZcsw)
- [Overview of the Practices](https://www.teachingchannel.org/video/science-engineering-practices-achieve) (https://www.teachingchannel.org/video/science-engineering-practices-achieve)

Crosscutting Concepts

- [Bozeman Science: 3D classrooms](https://www.youtube.com/watch?v=1g9CUY1TBS8) (https://www.youtube.com/watch?v=1g9CUY1TBS8)
- [Using Creativity and Imagination in Sense-making](https://www.youtube.com/watch?v=iN8xbyFZk0w) (https://www.youtube.com/watch?v=iN8xbyFZk0w)

Bundling

- [Bundling at Every Grade Level](https://www.nextgenscience.org/news/ngss-example-bundles-available-elementary-middle-and-high-school) (https://www.nextgenscience.org/news/ngss-example-bundles-available-elementary-middle-and-high-school)

Cultural Connections

- [Making Science Relevant to Indigenous Students](https://www.ictinc.ca/blog/making-science-relevant-to-indigenous-students) (https://www.ictinc.ca/blog/making-science-relevant-to-indigenous-students)
- [Indigenous Knowledge is Science](https://stemforall2019.videohall.com/presentations/1602) (https://stemforall2019.videohall.com/presentations/1602)