

Alaska Scientists of the Future



Curriculum Guide

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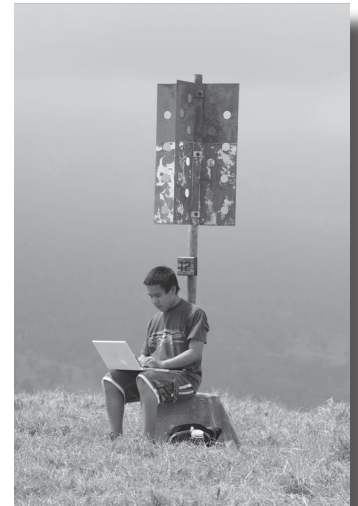
Foreword

In today's world our lives are deeply influenced by science and technology. There is a myriad of complex social issues involving science and technology that many Americans are ill-prepared to face due to a lack of quality education in these areas. Educating today's youth about these complex issues and their underlying scientific and technological principles are vital to the future of our society. Recent national attention has focused on the education of today's students in science, math, and technology. This type of education emphasizes complex thinking, collaborative efforts and decision making skills and is linked to the belief that education in these areas is critical to our nation's economic health, international economic competitiveness, and more recently our national security.

As expectations increase under national, state and local content standards, so do the stakes for what K-12 students need to know and be able to do in science and math. Nurturing careers of excellence and leadership in science and technology in today's students is an essential investment in America's national and global future. Programs that help keep the United States competitive in science and technology and further international understanding among future leaders of the world are fueling the educational reform efforts currently being seen in science, math and technology. Challenging students and assisting them with well prepared teachers on a long-term basis to become the creators, inventors, scientists, and leaders of the 21st century is the only way we as a country can compete in the global marketplace of ideas and innovation.

The shortage of underrepresented Americans in the science and technological workforce contributes to the overall shortage of information technology workers and leading American scientists. In order to address the long-term need for home grown scientists, programming for both youth-based and teacher projects is needed.

As education reformers grapple with the ramifications of national studies such as the Glenn Commission year 2000 report "Before



"We got to use the probes for testing salinity and all that. I thought that was pretty cool. I'd never known how to do anything like that. Then the computer put it in a graph for you."

*- Tina
Highland Tech Student*

It's Too Late", and the requirements set forth by new national education standards, the greatest hope for realizing change is often seen to be a better teacher. The ideal of the better teacher is not necessarily a new teacher, but a teacher with an understanding of new ways to approach the task of education. The 1996 National Science Education Standards (NSES) chapter "Standards for Professional Development for Teachers of Science" notes that the current reform effort requires a substantive change in how science is taught; an equally substantive change is needed in professional development practices. Combating how science is currently taught demands investment in science educators. The preliminary findings suggest that research experiences precipitate a cultural shift for the teacher and research scientist participants. In the case of the teacher, this shift will directly impact their work with students and colleagues. In the case of the research scientist, this shift may play an integral role in closing the gap between K-12 education and workplace practice of science.

The goals of this project are to research and share curriculum and best practices for educators and other stakeholders in the development of students into science careers for the future. We encourage you to "look over our shoulder" in using this Curriculum Guide and gain from our limited experience in seeking answers to this essential question. And then share with us and others your experience at www.futurescientists.org so that others may gain from your insights too. The future of a lot of really smart kids depends on our efforts, not to mention our global competitiveness as a country.

1 Introduction

by Mark Standley

Have you ever wondered why scientists choose to become scientists? When and how do they decide? Do some even decide or rather evolve into the role? What experience at what age is the catalyst for this career decision?

"There are two mistakes one can make along the road to truth - not going all the way, and not starting."

- Buddha

The word science comes from the Latin "scientia," meaning knowledge (www.sciencemadesimple.com). It describes a career choice, a path of inquiry, and a way of thinking. Most schools require students to reach a certain content knowledge and level of proficiency in science before moving into the world of work. Students experience science at school, at home, in museums, in civic organizations like the Boys/Girl Scouts, on TV, on the radio, and on the Internet. Yet no one is entirely clear about how these experiences and expectations translate into students wanting to pursue interests and a career in science.

The need for American born scientists is growing. The numbers of scientists and engineers at U.S. universities and colleges compared with foreign schools is declining. A lot of national attention and funding has been aimed at making citizens aware of, understanding, and addressing this critical problem. Our national security, business and global competitiveness, and post-secondary research strengths are often cited as the main goals for increasing the number of students who would choose science as a profession.

Yet how is that done? As the questions above begin our query into this topic, what is it exactly that causes a student to be drawn into the world of science? Beyond the structure of school curriculum, the requirements of learning science content, and the variety of intentional and unintentional science experiences, what are the variables that lead a child to a science career?

This curriculum guide for educators and policy makers is intended as a partial answer to these questions. We have pulled together some important ideas from science and other educational pedagogy to provide some research and curriculum to help ferret out what matters most in helping provide students a positive path towards science. The paths we describe in this curriculum guide include inquiry based learning, digital storytelling, hands-on science in the classroom and in the field, technology for science investigations, and assessments. We explain the methods we used for working with students in the classroom and the field.

The work, which is the basis for this guide, comes from educators, students, researchers, and business people interested in providing answers to this essential question about students becoming scientists across the US. Our work took place mostly in Alaska and one powerful field experience in Hawaii, hence the name "Alaska Scientists of the Future." But these experiences and insights could be in any state, any school and any student.

We encourage you to use this curriculum guide to inform your practice and policy decisions around experiences for students that includes inquiry learning, scientific methods, storytelling, technology, assessments, classroom and field based learning for your students. We will be actively pursuing these ideas and practices ourselves and invite you to share your experiences with us at our website:

www.futurescientists.org.

2 How to Use This Curriculum Guide

by Mark Standley

Most of science is about inquiry, experimentation, and observation. Scientists also share their research with other scientists and the public. This curriculum guide is for educators, scientists, and students who are interested in encouraging more U.S. students into science careers. While it seems true that no one path works for all students, this curriculum guide offers several important paths for schools and educators to follow. Those paths include inquiry-based learning, technology for science, storytelling, and focusing on key scientific concepts through hands-on, experiential, and standards based learning in the classroom and in the field.

"If you don't know where you are going, any road will get you there."

—Lewis Carroll

Within inquiry-based learning the questions are the answers. The emphasis on a plurality of questions comes from the importance placed in the sequence and scaffolding of inquiry throughout the scientific process. Rather than one question coming from a teacher looking for the "right" answer, inquiry based learning places an emphasis of a cycle of questions shared between the learner, the teacher, and the data. In Chapter 3 you will learn how to help students learn to think for themselves by developing their own ability to inquire throughout the scientific process.

If the adage, "anything that was not invented when you were born is 'technology,'" then for students today much of the technology-based tools for educators is not technology. Rapid changes in technology during the current generation's lifetime means they are ready to explore, sample, probe, analyze, and communicate with the "toys" in science. Beyond their readiness and natural comfort with technology, students need to take advantage of the wide-range of hand-held, portable, and relatively inexpensive technology in their science work. The other advantage in today's

technology is field-based analysis and communication in real time for scientists. Chapter 4 describes these advantages and how to bring these perspectives into your class and field-based experiences for students.

"Watching an Inconvenient truth was engaging for the students and inspired more conversation and discussion than was expected."

—Sheryl "Shoo" Salasky

All reporting in science is done to communicate new information with audiences. Scientists who master the skills of storytelling bring greater impact to their sharing results. Chapter 5 describes how to teach students to understand and communicate change through the form of a story. The tools include storyboarding, videography, editing, and media literacy through sharing scientific observations, analysis, and insights. Digital stories about their work provide students with the potential of larger audiences through web-based or DVD media sharing. Digital stories give students the opportunity to get more feedback and recognition for their inquiry and research. Learning from the content and impact of movies such as, "An Inconvenient Truth" (Halies) students get inspired and engaged about the power of digital storytelling. Ultimately storytelling gives them a better handle on how to connect the context and specifics of their scientific work with broader audiences with the greatest impact.

The last pieces of using this curriculum guides in Chapter 6 and 7 include a variety of classroom and field based activities that are provided for study and replication. You will find a series of science activities built about the Do It Yourself (DIY) curriculum and website. There are a series of tools and other activities for the classroom and field that educators can apply from this guide and/or from the ASOF website (www.futurescientists.org). While our scientific inquiry focused on global warming, you will find that any emphasis on important science questions in the context of these tools will provide students every opportunity to explore using these tools offered in this curriculum guide AND their own interest in a career in science.

Our emphasis has been within the context of a standards based curriculum and learning environment shared by the two school districts (Chugach and Denali Borough) and a school (Highland Tech) in this project. The assessments described in Chapter 8 revolve around rubrics, scoring guides, and clear expectations about outcomes from

their work. Our standards-based curriculum at each school site is a powerful vehicle for student-centered learning. All lessons and activities begin with using the national and state standards in Science. Assessments are done by students about their own work, peer assessment, as well as feedback from educators and researchers. This chapter will provide strategies for using a standards based assessment for science, inquiry, the technology, and the storytelling skills shared in this Guide.

No curriculum guide can offer the wisdom, insights, and enthusiasm that a real science teacher or researcher can offer to students. We recognize that the tools in this curriculum guide are powerful starting points and methods for all the talented and enthusiastic science teachers to use to help students see the joy and depth of scientific inquiry. We encourage you to study and apply these tools we have put together in this Guide with your own bag of tricks to help more students get connected to the world and careers in science.

Each chapter will model the Inquiry-Based Model that includes:

- Relevance of this topic to the goal of encouraging students to become scientists
- Main ideas
- Strategies to use in the classroom / field
- Words of wisdom we have gained through the experiences in this grant

3 Teaching and Learning Through Inquiry

by Alan Nakagawa

RELEVANCE

The use of inquiry is a pedagogical approach and an instructional outcome, or way of knowing and doing, and is fundamental to effective science education. The term “inquiry” is certainly well known to be central to the teaching of science but teachers frequently have many misconceptions and varying understandings of what inquiry means. Developing a clear understanding of Inquiry will be the first step in becoming an inquiry-based teacher.

“Let us examine this question together, my friend, and if you can contradict anything that I say, do so, and I shall be persuaded.”

—Plato

MAIN IDEAS

Scientific inquiry is not at all new to science education but educators have struggled with its implementation since the early 1900s (Bybee, R. 1993). As we look into our classrooms we can see inquiry being presented as a process (or method) and as content, but rarely integrated. Elementary schools typically focus on the processes skills (observing, identifying, classifying, etc.) of science while secondary science programs tend to focus heavily on content. It is essential that a balance between the process and content be established for students to engage in inquiry and to learn scientific concepts, formulate questions and propose explanations. Compared to traditional teaching pedagogy, inquiry immediately engages students to think for themselves instead of looking for answers that the teacher is asking for. Through inquiry learning students take responsibility and ownership of their own learning and gain a deeper understanding of the concepts and value of science.

The inquiry process is not so much a science as it is an art and the more our students practice this art the better they get at it. To do inquiry well our students need to know how to take the knowledge

"Inquiry based learning is more powerful when it starts in the classroom, because you can sit down together and formulate a question; figure out how to ask it. Then going out into the field to begin to answer it is exciting."

– Ayme Johnson
Highland Tech Teacher

that they already know and push its limits to explore the unknown. For teachers, it is the unknown that we typically have trouble with as we rarely teach, and therefore students rarely understand, the value of the unknown. The discovery of the unknown is the essence of inquiry and teachers need to guide students (through inquiry) to discover new understandings of our natural world.

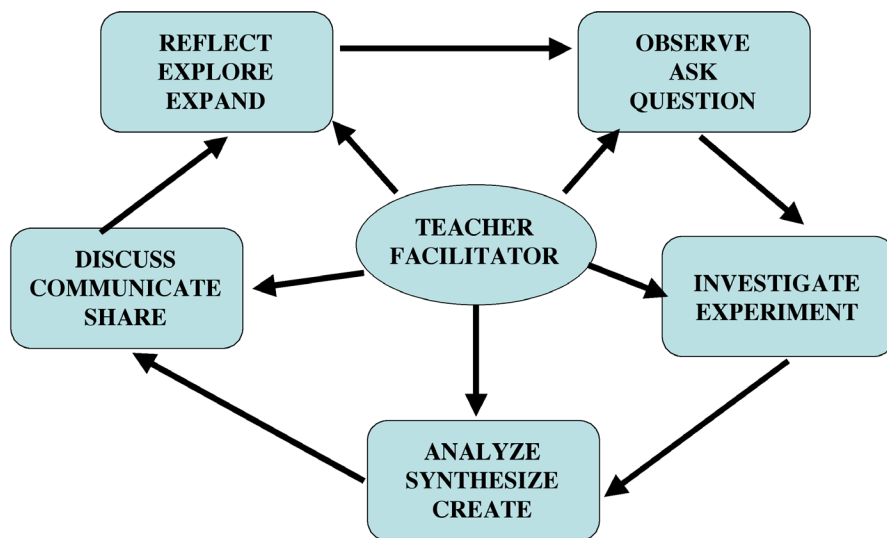
STRATEGIES

Inquiry is typically described as a process that includes:

- Observing
- Investigating
- Analyzing and giving priority to evidence
- Communicating
- Reflection

Inquiry is a cyclic process, which places a teacher in a facilitative role that guides students through each of the steps as can be seen in the graphic below.

Inquiry-Based Instruction



There are many changes that must take place as a teacher evolves into a facilitator of inquiry that connects student thinking to opportunities for learning. These opportunities for learning are designed and managed by teachers of inquiry and provide students with the resources and time that is needed for learning and doing science. This typically includes:

Collaboration with resources in the community

- Setting a school and classroom structure that is conducive to extended investigations.
- Providing students with necessary science tools, materials and technology to do science. Establishing a safe setting and framework for scientific inquiry.

WORDS OF WISDOM

The Alaska Scientists of the Future program has created a model that facilitates learning and teaching through inquiry. Students and teachers collaborate within and between schools as they develop ideas for inquiry that may come from their ideas/notes, learning web logs or content taught in school. Along with their teachers and resources from the scientific community, a discussion of inquiry will ensue that will be facilitated by prompts such as, “What if...,” “What do you think if...,” “What do you mean by....,” “What is the connection between...,” and so on. This begins the process that continues to expand through the inquiry cycle as students are taken on field experiences where they will apply their skills and technology tools in an authentic learning environment. The use of inquiry as a model for teaching and learning cannot be overstated. Skillful teachers engaging students in the development of scientifically oriented questions, based on authentic real world problems, will empower students to take charge of their own learning. Conversely, teachers that are most concerned about students getting the “right” answers diminish a students natural curiosity and sense of discovery that is so critical in learning and doing science.

4 Technology

by Dr. Bill Wiecking

RELEVANCE

Consider a student 100 years ago, in 1907: electricity is available in places, radio is just being invented, no TV, no electronics, experimental flight, rudimentary knowledge of medicine, astronomy, physics, chemistry, biology and the world around them. Communication is by letters delivered by train or ship, and the concept of an internet is beyond imagination. How did these students learn, and more importantly, what made them interested in science? Fast forward to the present, or more precisely, about 10 minutes into the future, where our students now live: the internet is almost ubiquitous, cell phones, IM chat, and online media are commonplace, and so are the tools available to them. How can we use these tools to inspire our students, building on what might have inspired them 100 years ago? As teachers, we know that curiosity and exploration are key elements in a successful learning experience. When students are exploring or inventing, there is no clock on the wall, and they need no urging to become engaged. Our vision is to capitalize on the emerging technologies already familiar to our students, augment them with new science and technologies, even prototypes that have not seen the consumer market, and enable our students to adapt, invent, and create a learning experience of their own.

Along the way, we hope to learn with them just what makes students want to become scientists.

About this emerging technology: we are riding a wave of technology innovation driven principally by the consumer market. The concept of a "digital hub" is one aim of the Apple Computer product development scheme, integrating many of these consumer level needs into a central unit. Fortunately, we can adapt and modify many of these needs and features for our work in field

"Inquiry into authentic questions generated from student experiences is the central strategy for teaching science."

*—National Research Council
(1996)*



studies. The need to capture, edit and share media is one aspect that can change how and where we interact within our field research studies.

MAIN IDEAS

One key element in our project is to determine just what makes students choose science as a field of study is the use of cutting edge research tools. These tools must at once be authentic, able to gather and share real data, as well as easy to use, and perhaps most importantly: modify. It is our belief that this process of adaptation and invention is key to the individual experience, and is at the heart of many scientists' experience. It may be using an emerging technology to study an older subject in more detail, or the ability to synthesize in real time data gathered by separate scientists in disparate locations. This paradigm shift may tell us more than just what makes students choose science, it may tell us how this wave of technology may be best ridden by scientists to further their research for the good of all. Our main tool in these studies has been the Apple MacBook laptop computer. With a two hour battery life, Intel processor, built in camera and wireless, it is the ideal combination of these consumer features adaptable by our students for field work.

STRATEGY

Our vision is to inspire a sense of invention in students, and by doing so, study what makes them interested in science as a career. We believe that by giving students access to authentic scientists doing significant work relevant to the students' lives, we can engage their curiosity, and further, by allowing them to invent and adapt cutting edge tools to their unique purposes, instill in them a sense of ownership over their experience.

We also believe that there is a sea-change underway in the nature in which field studies are conducted, from a research-gather-analyze paradigm to a process where all three processes are active at the same time. In order for this to happen in the field, students must have access to data, other researchers, and processing tools while in the field.

One example of this might be the study of an endangered species: students could be in the field, using online video/voice and data chat to share processes and exploration with fellow researchers both in the field and back in the laboratory. In one case, students used GPS and digital photos to track the re-emergence of plants after a fire. As the students walked around the field, they were able to show experts hundreds of miles away live video of certain emerging plants, asking if they were native or introduced. This sort of real-time synthesis of observation, data and synthesis has not been possible until recently as the tools below have been created and made available for our students. For remote access to these resources, we have been able to extend the range of these wireless "clouds" to tens of miles from any internet connection.

Once access to the internet is achieved, video can be shared with other students in the classroom, allowing the field observers to develop their skills as informed reporters, which is the philosophy of the scientific method, usually reserved for lab reports. In our case, students' conferences and chats are recorded and archived for further study.

The use of weblogs as an informal online diary also add to this "informed reporter" role, and in our observations, students take great care in the accuracy and format of these weblogs, often even more so than in many lab reports.

The use of GPS and when woven into a larger set of data the Geographical Information System (GIS) students can now implant this data into their observations, to weave a legacy quilt of information. Students years down the line can then use these data for comparison and analysis of trends. Again, students have a greater respect for their own data and processes if they know they will form the basis for further study. This is another key aspect of the scientific process, previously anathema to most students.

Many new tools are available for even the most modest programs, such as dissolved gas sensors, pollution measurement, and other

vital data previously unheard of for K-12 students. These data can be gathered first hand, or remotely, with the data incorporated into the data quilt mentioned above.

The same tools we use for research and development are used for publishing and dissemination of these data, be it over web pages, digital video or still photos. This ability to coherently communicate ideas is a key aspect to any scientists' profession. As you can see, every aspect of this process models in some way a larger goal and relevance to the life of a scientist. It is our hope to instill these concepts "under the radar" of most K-12 students, using tools that they are comfortable with and use every day, but what's more, tools they will find commonplace in their future careers.

As teachers, we are in a difficult and exciting place: we have to prepare our students for a life we can only imagine, using tools that are not even invented yet. We may not see this future, but they will. Our first grade students will retire in 2065. We can only make intelligent guesses on what this world will be like, but we passionately believe that if we equip our students with not only the best tools, but the ability to modify these tools to create their own learning experience, this is a lesson that will enable them to be great learners, and we hope great scientists.

Fortunately, we can adapt and modify many of these needs and features for our work in field studies. The need to capture, edit and share media is one aspect that can change how and where we interact within our field research studies. One key element in our project to determine just what makes students choose science as a field of study is the use of cutting edge research tools. These tools must at once be authentic, able to gather and share real data, as well as easy to use, and perhaps most importantly: modify. It is our belief that this process of adaptation and invention is key to the individual experience, and is at the heart of many scientists' experience. It may be using an emerging technology to study an older subject in more detail, or the ability to synthesize in real time data gathered by separate scientists in disparate locations. This paradigm shift may tell us more than just what makes students choose

science, it may tell us how this wave of technology may be best ridden by scientists to further their research for the good of all.

Case Study

Fire Re-emergence

Synopsis:

A fire has just burned through a remote forested area.

Students have the opportunity to study the rate, placement and identification of emerging species after the burn. Which plants are indigenous and which are introduced? How have the indigenous species adapted to the fires, which presumably have been part of their evolutionary survival in that location? How to map out the emerging species so that future students doing future studies can track the progress of both types of plants? How can spot analysis of soil pH, phosphate and nitrate levels be linked to the emergence of the native and introduced species?

Tools used:

GPS, Laptops with video cameras, still digital cameras, GIS integration software/server access, video teleconferencing, soil testing probes.

Process:

Using the GPS to locate plants, then using the VTC to communicate with experts, students identify and study the plants. Once identified, their field study is more informed, and can include exceptions, pattern development, and other higher learning aspects before impossible without field integration of the analysis tools. Once data is collected, it is uploaded to a server that all field students can access in real time, with photos and GPS/GIS integration, so students may change their analysis and study patterns all over the study area, not just with the one group. Communication with students in the classroom create "field reporters" acting as informed observers of the situation. This is all documented with chat recording programs for archival and study purposes. Students can upload weblogs and web pages of their experience from the field as well, with feedback from the students

in the field and in the classroom to enable a real-time synthesis of ideas. This demonstrates the purest form of inquiry based learning-this could not be scripted by a teacher, but is rather a synthetic learning process.

Case Study

Carbon Dioxide Sequestration: Global Warming

Synopsis:

Students in different parts of the world study sequestered carbon dioxide levels in glaciers and in ocean water. Purpose: to gather samples and develop trends in CO₂ levels, with the goal of integrating these measurements into a larger global research initiative.

Tools Used:

Sample gathering tools, GIS and GPS data recorders, VTC tools for communication with other teams, experts online, CO₂ and other sensors (UVA and UVB, infrared thermometers), laptop for integration of sensor data and communication with other teams.

Process:

Students gather glacial melt water, taking temperature with both direct and distant IR thermometers, gather fluid samples and test CO₂ levels, saved for later analysis in more complex lab settings (e.g. isotopic analysis). Trends in ambient ice temperatures are then linked to hypotheses on gas solubility and other patterns that may change from year to year. GIS integration allows for legacy studies to determine micro-environmental impacts.

Case Study

Ice Pond Thickness: Global Warming

Synopsis:

Winter ice is thinning, possibly as a result of global warming. Field studies of this thickness can be used to relate first hand observations back to classrooms with the goal of integrating the field experience with global CO₂ readings and trends.

Tools Used:

Laptop with VTC, GPS and GIS integration for legacy studies, photos linked to GPS and GIS data for relation to other similar sites, long term thermometers (HOBO units) for autonomous year-round measurements, again to determine trends. These data would then be shared with other groups via the websites composed with field data.

WORDS OF WISDOM

It has been our experience in years of these studies that once students are familiar with the equipment, the course of study becomes something they easily comprehend, as well as how to use their tools to gather data for study. The key element we bring as teachers is the concepts of scientific progress built on honest, accurate data collection. It has been our experience that once students sense that their data is part of a larger, later whole, they take greater care in the gathering and processing of the information involved.

So, what did we learn? In an important conference on the deployment of the newly invented SCUBA, Jacques Cousteau asked the assembled group, "Yes, but will it be fun?". As teachers we believe that any project involving kids should be fun, but further, do they carry anything away? What are the meta-messages we have conveyed in this project? We believe that students have learned more than just how to use new tools in new ways, but to invent their own use for the tools. It's at once an inspiring and scary moment for many teachers: give them the tools, then be prepared for the moment when you say "I had no idea you could use this in that way". This is the moment when the student becomes the teacher, and in doing so, the student has created something unique, and in the process been inspired to go further. Perhaps this is the higher purpose of our study: not just to watch students engaged in science to gain insight into what makes them choose science, but to delve even deeper into what makes hands-on education successful: the act of creative ownership.

5 Science and Storytelling

by Mark Standley and Roxy Kohler

RELEVANCE

When scientists are ready to share their work, what's the best way to communicate their findings? We believe there's the risk of losing truly great findings in what has come to be called, "power pointless" presentations at conferences and scientific seminars, much less explain things to the non-scientific community. What if students learning to share the "story" of their data in ways that were clear, well thought out, and easily understood by the context and structure of the presentation....powerful storytelling.

"Every community has a memory of itself. Not a history, nor an archive, nor an authoritative record..."

A living memory, an awareness of a collective identity woven of a thousand stories."

—www.storycenter.org

The Alaskan Scientists of the Future (ASOF) promotes critical thinking, media literacy, and powerful storytelling to educators and students around the world. Through organized trainings, workshops, and camps in urban and rural areas students and teachers learn skills in powerful storytelling, videography, and social marketing. These trainings take place in schools and in wild areas (i.e. National Parks) teaching students field-based research skills, personal/artist expression, and place-based values. Students produce "stories" of the research and places they experience to audiences in powerful ways to communicate the science and aesthetics of a location. We define "powerful" to connote a story that influences audiences into some action based on the ideas, findings, and compelling facts of the scientific research. Our teachers used the Academy Award winning movie, "An Inconvenient Truth" for both science content and exemplar of powerful storytelling.



MAIN IDEAS

Storytelling has been a tradition in almost every culture throughout time. The 'voice' used in relaying information, lessons, beliefs, cultures, methods is critical to how the story is used and understood. For scientists, the stories include theories, methods, assumptions, experiments, and discoveries. Stories can be told orally, through research papers, as a movie, on chat sites, as blog postings, forums, etc. For this project, we chose to use several approaches to share our stories, including face-to-face, video conferencing, blog sites, and digital still and video documentation of activities and reflections.

Tools used equip students with the academic, social, and technical skills to excel in today's world and contribute positively to our society and the future. Throughout the process of forming site teams, conducting activities inside and outside the classroom walls, and completion of field camps, students communicate experiences, results and real-world connections through site blogs, camp blogs, web page updates, video editing, iBook design, and postings/comments on ASOF web pages. Students' learning is validated through the process of gathering digital evidence and then telling their stories. They use their unique voices to reflect and learn from each other. The technology is exciting to the students, and it engages them in cutting edge technologies that prepare them for careers in the 21st century.

Storytelling allows dissemination of knowledge and research, as well as innovative models and resources, to a national and international audience. Students and teachers share the "story" of their data through the project's research and experiences. Teams share stories, such as the value of preserving and protecting lands for future generations embracing the cultural heritage of Alaska's Native people.

Scientists conduct research in private and in public depending on the nature of their projects. They must be able to communicate their theories, data, and conclusions in ways that other people can understand. To simply offer piles of technical data or findings couched in scientific gobblegook prevent effective communication between the science team and a non-scientific audience.

Scientists can use the storytelling process to share their work. Science through storytelling does not connote “dumbing down” the scientific language or findings. Rather it means giving the audiences the cognitive tools (vis-a-vis a story) to understand the changes over the course of the investigation and the implications of the findings in a specific and larger context.

Students, as scientists of the future, need to learn to effectively communicate their ideas and research. Feedback from audiences who comprehend these scientific “stories” will likely give clear and useful feedback to these scientists. That feedback will play an important role in validating the students perceptions of themselves as scientists. The negative connotation is of scientists who become isolated or disenchanted with their relationship with peers or professional audiences. The positive strokes from being heard and understood increases the likelihood of these students pursuing science careers.

STRATEGIES

Storytelling is implemented in the ASOF project through a main web site, explaining the objectives and outline of activities, giving references for support and curriculum developed. Each district created a separate web site that includes blogs, digital evidence of inquiry-based science projects, and videos created by the teams of students, teachers, and science experts in the field. Camps included separate web sites, blogs, and video documentation of the processes. Each camp also included a “boot room” experience where a video camera is set up for interviews throughout the camp experience for expectations, reflections, and honest feedback of how students learn.

We used the following script and strategies to teach storytelling to our ASOF students and teachers:

Everyone has a story. What you choose to share with others will be your personal preference. What is your story? We will begin with looking at some stories and writing about what they mean to

us. What was the intent of the author/creator? What could they have done differently? How can you apply some of their techniques? Remember to keep in mind, as you tell your story, the reaction / interpretation you originally had in your storyboard.

When creating stories, think about the following elements. How can you make sure you are intentional about them? How do you include them? How do you make your story interesting to others?

Essential Tools Used in Digital Storytelling

Elements:

- Plot
- Economy
- Soundtrack
- Gift of Your Voice
- Point of View
- Dramatic
- Emotional
- Pacing

Storyboarding:

We used two primary strategies to teach storyboarding. What we recommend is to ask students to recreate deductively a scene from a favorite movie recalling step-by-step how the film maker made a powerful scene come together frame by frame. Students will want to “study” these scenes in the context of storytelling elements (from www.storycenter.org).

Which of these elements made th scene powerful? What made this powerful? How was the scene developed and filmed? Fire, ready, ... now create a new storyboard from the student’s imagination.

The second storyboard is inductive scene using the same storyboarding format from above. They should ask themselves what element they intend to emphasize. What will change in this scene? (ie scientists did NOT know there were dinosaur fossils in Denali National Park, now they do; exotic species are taking over critical habitat in wild parks on the heels of unknowing visitors...what can they do?).

Filming/Editing:

The storyboard is the really hard, fun, and MOST IMPORTANT part of storytelling. It's where the creative ideas and good storytelling techniques are formed, developed, and planned. The rest is just film making....although that takes a lot of skill. Using a tripod matters. Shooting what's in the storyboard matters with some improvisation depending on the situation, science, and team decisions. Editing just comes naturally if students work from a storyboard AND keep a clear sense of what story they want to convey. Lot's of great editing software (i.e., iMovie) makes this part of the storytelling process fun and creative. The rule of thumb for editing is to KISS (Keep it Simple, Silly). Let the scenes, plot, dialogue, and compelling issues tell the story; not the camera and whiz-bang transitions.

Publishing:

Our ASOF students edited the movies for DVD and the web. You will find copies of them on the DVD in this Guide and at www.futurescientists.org. Make sure the movies your students create find wide audiences that give them constructive feedback using the rubrics we have used or others (www.teachingstory.com). Publishing is another way for students to get the relevant feedback about the impact their story (the presentation of compelling scientific research) has with audiences. Students will expect to get helpful and non-helpful feedback. The really important thing is to stick with the rubrics, the story, and their instincts about what to add, take away and what to not change.

Share your stories (DVD, Web-blogs, Utube, etc) widely and learn from every bit of feedback to learn what makes a story ho-hum and what makes it powerful. The secret is to keep learning from every story. Every storyteller can get better at telling powerful stories using science, imagination, and learning to listen to their audiences.

Personal: Emotion & Intellectual

- Teaches others how to use emotion to support the message.
- Content causes audience to want to be active in the cause.
- Story caused emotional response (laughing, crying, reflecting, surprise).
- Content showed depth of issue(s) presented.
- Story caused emotional response that was predictable.
- Content was factual and accurate.

Social: Perspective, Creativity

- Teaches others how to use the “voice” of the story to present different ideas.
- Story includes creative ideas and techniques that others will want to use.
- The “voice” of the story is unique from first person, or third person.
- Story includes some unique ways of presenting the issues.
- Story is predictable, from one person’s point of view.
- Story includes something unique.

Technical: Still, motion, transitions, filters, special effects

- Teaches others how to use a tripod, take clear, focused pictures.
- Teaches others how to use special effects to make the story better, without distracting from the message.
- Photography enhances the message, with clear focus and no shaking.
- Filters and special effects are not obvious, but help tell the story in creative ways.
- Photography is focused and clear.
- Transitions are smooth and consistent.
- Filters and special effects don’t distract from the message.

Project Management: storyboard, timeline, shooting, editing, final product production

- Teaches others how to set and meet goals.
- Models effective use of a storyboard.
- Final product is done when originally planned.
- A storyboard was used to pre-plan the scenes and shoots.
- Editing took less time than half the total project.

- Final product is completed on time or prior to original deadline.
- A storyboard was drawn up.
- The timeline was used most of the time.

Impact: Clear message, audience reaction

- The message is repeated by others.
- The audience reacts in a way that is intended.
- The message is clear.
- The audience has a reaction.
- A message is attempted, but unclear.
- Some of the audience responds.

WORDS OF WISDOM

The ASOF project began with a face-to-face training with teachers and scientists for three days to learn concepts and processes for inquiry-based learning and storytelling. The boot-room concept was modeled and explained, but would be stronger with more training for on-site teachers to feel comfortable with the technology and process for future use. Now that we have completed our first year, videos have been developed that can solidify the power of storytelling, demonstrating how ideas can be conveyed through voices that are student-to-student.

Reading and hearing about inquiry-based learning is helpful, but hearing individual students' stories and videos showing camp activities and scientific processes makes the connections for others to understand and implement ideas that can be built on.

What's in a story? The organization of facts, patterns, things that change over time under the influence of various factors. Scientific study is a perfect format to grow storytellers, who can express for audiences the context, the changes, and the relevance of their work. The feedback young scientists receive from these stories are going to engage them and encourage more science. Students who understand how to organize and present complex data within the structure of story and through video will indeed be the scientists

of the future. They will be the men and women who do the science, yet share their work in compelling ways that will help others “act” on the information for more research, more funding, and/or more community action.

6 Classroom Activities

by Carolyn Staudt and Marcia Howell

RELEVANCE

Have you ever wondered how to engage students in the classroom? What will spark their interest and capture their imagination? Science in the classroom may be thought of as mundane, or old school, especially by students who are used to interactive technology, and instant results. All of this is possible in the classroom, especially with the use of exciting and novel technological tools.

MAIN IDEAS

This section of the curriculum guide is designed to provide you with new ideas that can be implemented in the classroom. It is also here to reduce any technology fears that may exist when it comes to introducing sensors, and gauges and other technological tools that we know our students will figure out how to use long before we do.

For most students the classroom is their first and primary experience with science. It's critical that educators engage students through inquiry, technology, and storytelling within the context of the classroom. Students who experience limited, inductive, and didactic science may be turned off. Students who experience true inquiry, questions that lead to answers that lead to questions, and hands on learning with science around relevant issues report higher levels of engagement.

In this chapter, in the accompanying appendix and on the ASOF website (www.futurescientists.org) there are a variety of sources of guidance on classroom activities that will inspire scientific inquiry by students.

"Students get super jazzed about using the probes in the classroom. It helps them connect math to science. They get to see it in real time; how data is gathered, and how you can alter intervals it takes it to that next level. Bridging that gap is cool."

"Inquiry based learning is more powerful when it starts in the classroom, because you can sit down together and formulate a question; figure out how to ask it. Then going out into the field to begin to answer it is exciting."

*—Ayme Johnson
Highland Tech Teacher*



STRATEGIES

Students participate in classroom activities in their respective school sites. Teachers used their own and shared curriculum to explore inquiry-based learning, technology for science, storytelling, and global warming. These activities are shared in the appendix, as well as at the ASOF website (www.futurescientists.org).

"If I could do what ever I wanted for an entire day, I'd just live. I'd go on a massive totally jubilant spree. Have as much fun as is humanly possible."

- Walker
Whittier Student

Do It Yourself (DIY) Activity Portal

ASOF DIY website (<http://onrdiy.concord.org/>) is a web application built using Ruby on Rails (<http://www.rubyonrails.org/>) that supports simple template-based authoring of highly interactive Java-based learner materials in which powerful exploration, modeling, and construction tools are combined with implicit and explicit embedded assessment. Rails is a full-stack framework for developing database-backed web applications according to the Model-View-Control pattern. From the Ajax in the view, to the request and response in the controller, to the domain model wrapping the database, Rails gives you a pure-Ruby development environment. To go live, all you need to add is a database and a web server.

In effect the DIY web application dynamically constructs a custom Java application for each authored activity. The DIY system delivers these activities to learners as Java Webstart applications that can run on Windows, MacOS X, and Linux computing systems. All the work a learner does in the activity is saved to a database managed by the DIY web application. This means that work on an activity a learner does at school can be continued at home and the teacher can review any work done by a learner.

You can easily create a new activity from the 'Activity Listing' page. You can start by either clicking the 'Create New Activity' link at the top of the page. This gives you a brand new blank activity to start with. Or you can start by copying someone else's activity by clicking the 'Copy' link at the left of each activity listed. Any of the Activities that authors have made publicly visible can be run as a Java web start application on your computer by clicking the 'Run' link.

When you create or edit an activity as the author you can decide

whether you want the activity listed as 'Public'. This is available as a check box on the Create or Edit activity pages. At the bottom of each activity listing is a link to a Usage page, which allows you (and anybody else) to see who has run your activity. You can 'View' the work that people have done from this page by clicking on their name. When you 'View' instead of 'Run' and activity no data will be saved back to the ASOF DIY web portal.

WORDS OF WISDOM

It is okay for teachers and students to learn together in the classroom. The introduction of technological tools used by professionals in the field entices and encourages students to believe in their own efforts, and helps them develop inquiry skills in the classroom. While it may be intimidating to ask students to use an infrared thermometer, a gas sensor, or another tools, knowing other teachers share that feeling may provide some comfort. Better yet, knowing how to access an online resource where teachers are sharing their challenges and successes will inspire and excite. We believe that peer to peer education and assesement is effective for our students. Peer learning with technology in classrooms can be a powerful vehicle for encouraging scientists of the future.

7 Field-Based Learning

by Alan Nakagawa and Mark Standley

RELEVANCE

Have you considered what difference field-based experiences have for getting students engaged in science? What do students experience in the field compared with the classroom? Have you surveyed students to assess the “learning quality” difference they experience in both locations? What’s been your own experience(s) with the quality of the learning working inside a lab/classroom and/or field-based research?

“Man’s mind stretched to a new idea never goes back to its original dimensions.”

– Oliver Wendell Holmes

MAIN IDEA

How often do students get to experience science in the natural world? Field-based experiences create the opportunity for students to step out of the “box” of school and science labs to sense first hand the power of scientific discovery in nature. Logistics, often viewed as an obstacle, can be a learning opportunity if students are engaged in the planning process. The necessity of teamwork in planning the logistics and research design for field-base experiences offer meaningful opportunities for students to become engaged in “fresh air” science. The sights, sounds, and smells of field-based experiences seem to heighten student engagement with science. Based on this project, we believe field-based experiences are an essential part of creating scientists for the future.

STRATEGIES

We know that science occurs indoors and outdoors. In this project we had students experience and reflect on the relevancy of both to an interest in pursuing science. When you read their blogs (www.futurescientists.org), you’ll find rich descriptions of how much students valued their experiences in the field. Field experiences seem to make science more “real” to students as they sample live ecosystems, streams, or habitats in nature. We know that science

in the field is not more real than classroom-based, but the physical reality of being outdoors seems to engage more of the students ability to observe, demonstrate active learning, and heighten their sense of relevancy for science. We will posit that both classroom and field-based experiences are relevant to future scientists. But we also offer that the true strength of field based experiences comes from the degree to which they increase students' awareness and appreciation for sciences and scientists' role in sampling, studying, and making sense of the patterns of the natural world.

"I'm an 'outdoors kind of person', learning outdoors keeps me paying attention. I was surprised by how much I learned at the Denali camp."

*- Adrian
Tatitlek Student*

Students sampling, analyzing, and sharing data in the field learn to work with and overcome many of the barriers in doing field science. Many of those barriers (weather, terrain, heat/cold, etc) are controlled in the classroom but many times are not or cannot be anticipated in the field. Environmental variables, such as the weather, that are many times taken for granted in the classroom can turn into a major obstacle that students need to learn to either anticipate or creatively adapt to. Through these kinds of experiences students become better thinkers and problem solvers that will in the end make them better scientists.

It's easy to speculate this physical quality of getting out of the school to do science causes students to engage both physically and emotionally with the work. We asked students to engage physically in the science of data gathering, sampling, analyzing, reporting, and storytelling from the field. They used a lot of hand held technology, common sense, teamwork, problem solving, and inquiry in the process of doing science in the field.

Activities used in the field with ASOF students:

The Alaskan Scientists Of the Future (ASOF) DIY activity website (www.futurescientists.org/3.html) was built at The Concord Consortium (www.concord.org). There are currently approximately 70 activities published that combine the probeware component technology and interactive computer models. These activities were developed to enhance the students experience in the field by allowing the students to create, customize, and share their work. Samples of these activities can

be found in the Appendix in this Curriculum Guide. View a list of the present activities at www.futurescientists.org/3.html.

During both of the field experiences on the Big Island in Hawaii and in Denali National Park and Preserve students used ASOF technology to collect data that helped to understand how climate changes affect our environment. During each field experience students created driving questions, proposed their hypothesis, probed the environment, and evaluated the results to attempt to answer their questions. During each experience, students created blogs and video stories (www.futurescientists.org/7.html) of their experiences to share with the students back at their schools.

Big Island in Hawaii

(www.futurescientists.org/7.html)

Students surveyed the ground surface temperatures with the IR thermometer in and around the Big Island. Students used this probe to measure the reflected infrared radiation of various vegetation types in a dryland forest of PuuWaaWaa as well as ground temperatures at Kilauea. "How does it compare to average temperatures on the Earth?" and "How does the volcanic activity on Kilauea affect temperatures?" were included in their research.

Using the Light sensor students calculated albedo found by dividing the amount of reflected light by the amount of incident light of various locations and environments. They researched questions such as, "What type of vegetation has the highest albedo value?" and "How does it compare to the earth's albedo value (.37)?"

With the CO₂ probe students determined how much CO₂ is emitted by various substrates and measured the amount of CO₂ present in various locations on the island. Their driving question was "How does volcanic activity affect the level of CO₂ in the atmosphere?"

"I like hands on learning and fresh air. We get our own air and we don't have to be in a room grouped with people. And Denali was the first time I've ever taken a 7-day field trip that was legitimately a part of school."

*– Gerry
Highland Tech Student*

Students researched the amount of UV radiation being reflected by different ground cover in the area and the effectiveness of their sunscreen or sunglasses with the UV radiation probes. They analyzed their results while thinking about the following driving questions:

- *Is there a relationship between UV radiation and Global Warming?*
- *Are increases in UV a result of Green House gasses?*

An Imhoff cone is simply a cone-shaped plastic container. It holds one liter, with the side of the cone graduated in milliliters. The cone is about 14" tall. Because the cone is very pointed (about 15°), the bottom 2" end of the cone holds only 20 ml. In comparison, the top 2" holds 300 ml. When a liquid is allowed to sit in the cone, the suspended solids settle to the bottom within a few minutes. Since the cones are made of clear plastic, it is easy to see the level marks between the settled solids, the clear liquid, and floating solids (if any). Students filled Imhoff cones with water from the Nenana River to study:

- *What the level of sediments that are being carried in the Nenana River?*
- *What kinds of sediments are being carried down the Nenana River?'*
- *Is there a difference between the amount of sediments in the Nenana and other rivers/streams in Denali?*

Turbidity is a measure of water's lack of clarity and is an important indicator of water quality. The cloudiness or turbidity of water is produced by light reflecting off particles in the water....more suspended particles mean more turbidity. High turbidity can be detrimental to water quality as more sunlight is absorbed, causing an increase in water temperature. According to the USGS, the turbidity of surface water is usually between 0 and 50 NTU. Turbidity is often higher than this, however, especially after heavy rain or (in the case of glaciers) warmer climate conditions when water levels are high. Students used a turbidity sensor on the Nenana River to answer questions including:

- *What is the relationship between turbidity and the amount of sediments in your river samples?*
- *Is there a relationship between river/air temperatures and turbidity?*

The ProScope™, a digital microscope connected to the computer, can be used to record digital images, digital video and time lapse (time lapse can also work with other firewire cameras like the iSight) with just a click of a button. Students used this digital microscope to take a closer look at the sediments collected along the rivers and streams and to identify organic matter and differentiate between glacial silt and soil. They also answered these driving questions:

- *Can you see any type of microorganisms in the streams/rivers in Denali?*
- *Do the glacial fed rivers have more/less microorganisms?*

Students tracked their routes of the various hikes in the park and along the Nenana River using the GPS. A Global Positioning System (GPS) is used to locate and identify data points of interest depending upon the problem being investigated. The Global Positioning System (GPS) is a worldwide radio-navigation system that uses satellites in space as reference points for determining locations on earth. It is formed from a constellation of 24 satellites and their ground stations. The satellites orbit the earth (north/south) twice a day at an altitude of 11,000 miles. A handheld GPS uses the satellites to calculate locations with about one meter accuracy. Students also collected their data with the CO2 sensor using software that identified and recorded the latitude and longitude of each measurement so the students could map their data.

WORDS OF WISDOM

Have you had to a chance to reflect on the difference field-based experiences have for budding scientists? The physical challenges, the excitement of being outdoors, the sense of wonder from making meaning of a small part of an expansive outdoors, sharing data real time with other students/scientists, and the emotional catharsis of natural beauty. All of these are factors in the power that field based experiences hold for helping to engage students in science.

"The informal nature of the camp allowed for teachable moments, and it may have helped create an atmosphere that fostered remarkably mature student behavior."

*- Shoo Salasky,
Chugach School District*

We believe that creating scientists of the future without a field-based experience is nearly impossible. Our students offer (through their blogs and storytelling) that the field based studies were the nexus of their experiences during the grant period. The next step is up to you. Using the strategies we have shared in this chapter AND your own sense of relevancy of field-based experiences, we'd strongly encourage you to overcome the logistical and bureaucratic challenges that keep science experiences only in the classroom. The students will be glad you are willing to think and act outside of the "box" of school in encouraging their pursuit of science.

8 Assessments

by Roxy Kohler

RELEVANCE

Assessments are at the center of learning. Using multiple types of assessment allow students to demonstrate mastery of learning doing what they do best to strengthen their confidence, and also to stretch their abilities; whether it is a skills-based test that shows they have the knowledge, or more of a portfolio style, demonstrating the knowledge, each method has validity.

"Insanity is doing the same things over and over again and expecting different results."

—Albert Einstein

The Alaska Scientists of the Future (ASOF) activities are driven by state and national science standards. For inquiry-based learning, instructors conduct a pre-assessment to help students and those working with them determine what knowledge they already possess and where to go from there. Across America we have national content science standards, as well as our own local state and district standards. Some schools have their own school standards, combining the national, state, and district standards into a user-friendly list of competencies, that are vertically aligned throughout the levels to insure the integrity of the national standards are kept intact. These are guidelines to help determine what students need to show mastery of, but more importantly, what experts feel students will be able to demonstrate, especially as they continue on towards becoming scientists of the future.

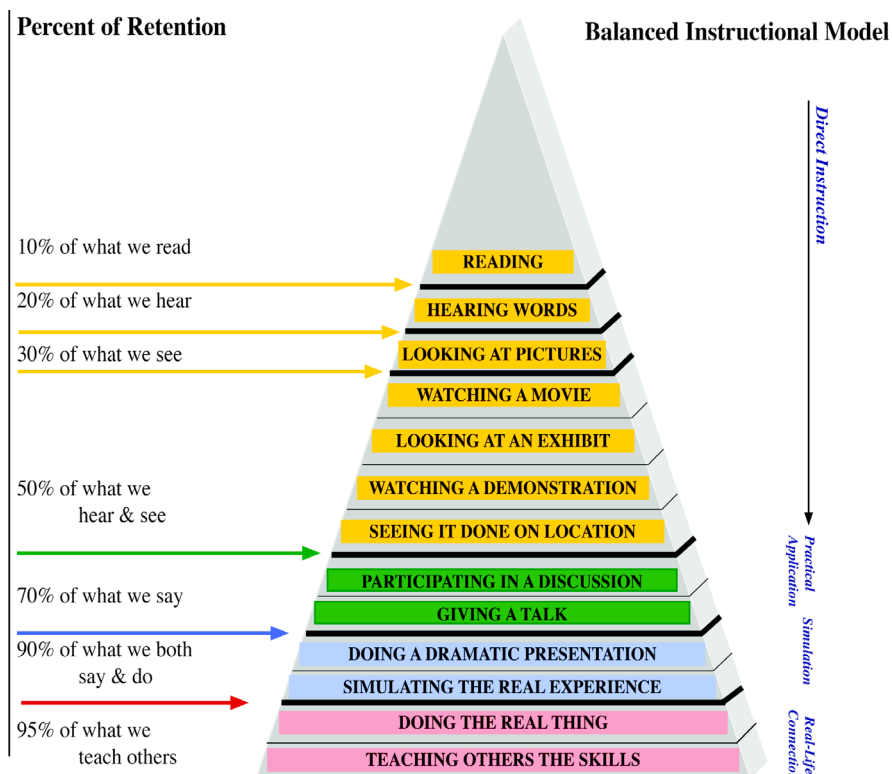
MAIN IDEAS

Assessments can be conducted through multiple avenues:

- Skills-based = "knowing it"
- Analytical = "doing it"
- Contextual = "living it"

Students who have the opportunity to apply and "live" their knowledge are more likely to retain and build on it. As teachers,

we need to apply multiple assessments throughout the learning experience. This draws on the strengths of the students, as well as provides multiple opportunities to determine what has been learned and where the holes still exist. Multiple assessments provides students opportunities to show what they know, gaining confidence in their abilities and the desire to learn more.



Developed and revised by Bruce Ryland from material by Edgar Dole. See also: *Fostering Critical Reflection in Adulthood*, by Jack Mezinow & Associates, San Francisco: Jossey-Bass, 1990.

STRATEGIES

Skills-based assessments are a quick way to check for understanding and find obvious gaps in knowledge. An example of one test is a pre-assessment. This type of assessment is conducted with students prior to starting grant activities. This can be done through a multiple-choice questioning technique, a web-based test, or even an oral exam.

Analytical assessments allow students to show knowledge through projects and hands-on activities within a simulated situation. Examples of these assessments use a rubric format:

STANDARD NAME	STANDARD DEFINITION	Advanced	Proficient	Developing	Emerging
Ecology: organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy					
Science Ecology Level 4 4.01 National & State Content Standard D	• Describes the carbon cycle and relates it to global climate change	• Describes and illustrates the carbon cycle	• Describes and illustrates the carbon cycle	• Describes or illustrates the carbon cycle	• Describes or illustrates the carbon cycle

The ASOF students who participated in camps and school-site activities each created blog sites to post their findings, as another way to assess what they learned, in their own words. More examples are posted in the Appendix.

One strategy we used in the ASOF project is what we call the "Boot Room." This was created originally at a camp in England. We set up a quiet room with a video camera and a list of questions students could come answer at any time, alone, without fear of having anyone else in the room. We solicited comments and ideas of activities they were doing, as well as methods used, to gain true, honest, candid answers that they may be reluctant to share in other ways. The only room that was dark and quiet enough ended up being the "boot room" entry, where students removed their boots and shoes before entering the facility. The name the "Boot Room" stuck as a strategy that we used throughout other science and storytelling camps. The procedure for using a "Boot Room" is as follows:

- Step 1 = Get forms / posters / questions ready
- Step 2 = Designate area and set up
- Step 3 = Train staff and students
- Step 4 = Collect data
- Step 5 = Analyze / compile data for use in feedback response actions

For more information on specific project ideas and strategies, please check out the ASOF web site: www.futurescientists.org

WORDS OF WISDOM

Students who have participated in grant activities from the three districts involved have demonstrated mastery of learning, and even

better, create excitement for science. The camps that they were able to travel to provided opportunities to test their knowledge in the field, while using technology-based tools to conduct experiments, as well as communicate with others who were not able to go. Using video conferencing, blog sites, presentations at conferences and in the classroom, students have not only shown mastery of the national, state, and district standards, but are testifying how excited they are to learn more about science and pursue a career as a scientist.

9 Conclusion: Creating Scientists for the Future

What makes a student want to go into science? Perhaps we can find the answer by asking another question: what makes scientists stay in science? The answer we have discovered from ASOF students and teachers is that they feel engaged in a process of unique discovery, one in which they are active participants in the contribution to their field of scientific research. It is this sense of participation, contribution, and authentic discovery that we have studied in this project.

*"It is today we must create the world of the future."
—Eleanor Roosevelt*

We have looked at various ways to measure, predict, and evaluate experiences that our students have shared:

- Perhaps the most telling data is not that which can be summarized in a report, more quotes from student interviews in sidebars in this Curriculum Guide that help us measure our students' internalization of ASOF project goals.

Our model is one of using cutting edge technologies in new and exciting ways, some of which we can only take part of the way for our students, leaving the process of invention to them. One-on-one contact with authentic scientists serves to demonstrate that if these people have dedicated themselves to arcane subjects of study, there must be a reason... "what could that be?"

This is the question we hope to engender with this project. It is our experience that when students feel that they are the first to combine new tools in unique ways to study a subject of world-wide impact, they can feel as engaged as the scientists they are working with.

Field studies often center around an area, a toolset, or a species under study. In our project, the global concern of CO₂ induced global warming was chosen not because it was in the news (the topic was chosen a full year earlier), but because it could be studied in different parts of the world, by similar students using similar tools, each in unique ways. This distance factor was another hidden aspect of our study: It lent itself to the use of video teleconferencing and distance independent educational opportunities, while also opening the eyes of students, looking out and looking in to remote villages.

One analogy for our choice of locations is that of the scientific community as a whole: disparate labs working on similar aspects of a common problem of great concern to the members, using similar but not identical tools, communicating as colleagues. Here again we are modeling what it is like to be a scientist.

If we have been successful, we have done so on two levels at least: first, we may have opened our students' eyes to the possibility of being a scientist, but more far-reaching, we have learned how to measure the efficacy of various approaches to influencing this change. We have created and tested an interview process, a method of evaluating interest and pre-knowledge of a common topic. We've exposed our students to invention, study, discovery, storytelling and the process of science. While some of our results will be part of this Guide, others will require years to become evident, most notably in the choices our students make.

Where do we go from here? Certainly we should monitor the long term effects of our project, but we should also publicize our process for others concerned with the education of our future scientists. Like the scientific process itself, it is our hope that those who follow us will learn from our successes and our failures to create an improved version of what we have set out to do.

Appendix I

Help With Technology Tools

STRATEGIES

1. Communication/interaction
2. Data gathering/synthesis
3. Remote Access
4. GPS/GIS integration
5. Media production/viewing/editing
6. Repair maintenance

When viewed as a device with attachments, an outline comes to mind:

1. Communication/interaction

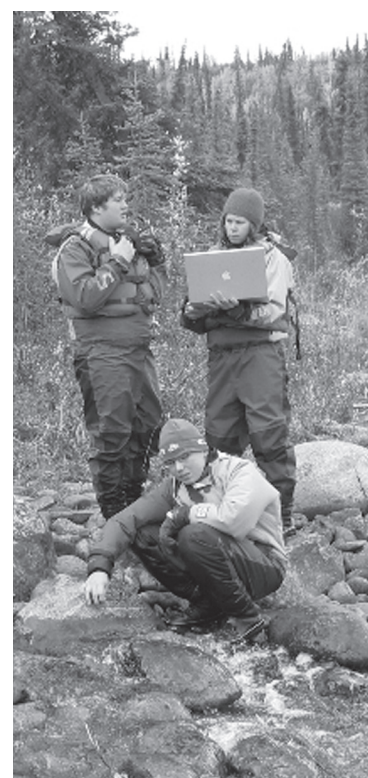
- 1.1. Web access
- 1.1.1. weblogs
- 1.2. iChatAV videoconferencing
- 1.3. Video viewing/dissemination/storage
- 1.4. email/IM chat
- 1.5. Skype/Vonage VoIP conferencing (computer to computer or land line)

2. Data gathering/synthesis

2. Vernier Logger Pro 3.5 integration
- 2.1. temperature, radiation (UVa, UVb, visible)
- 2.2. pH, salinity, NO₃, other liquid levels
- 2.3. adaptable to long term or short term measurement
- 2.4. gateway to HOB0 or other autonomous data collection devices
- 2.5. Data storage/integration/synthesis in real time with collaborative partners

3. Remote Access

- 3.1. realtime field collaboration
- 3.2. local cloud of several hundred feet
- 3.3. when integrated into larger cloud, range of 12 miles solo, 46 miles with repeaters for remote field work
- 3.4. provides one-click video and text messaging with ability to share



documents, data, photos, other formats produced locally
3.5.802.11b for legacy systems, 802.11g for 54 mb/s systems, 802.11n
for 600mb/s systems, all transparently switched.

4.GPS/GIS integration

- 4.1.realtime collaboration with native mapping and tracking programs
- 4.2.data tagging for legacy studies
- 4.3.integration with ESRI or other GIS products (under true windows OS)
- 4.4.Synthesis in real time with collaborative partners using web or local wireless networks

5. Media production/viewing/editing

- 5.1.Capture live video and stills with built-in camera
- 5.2.edit/produce and share locally or with DVD burner
- 5.3.disseminate with web access to storage/media server for group access
- 5.4.local server capacity with team leader laptops
- 5.5.integration with GIS and GPS databases
- 5.6.flexible and adaptable for use with other databases (e.g. FileMaker Pro)

6. Repair maintenance

- 6.1.all units come with toolset for field repair of other machines
- 6.2.team leader units have master clone images for total recovery
- 6.3.data transfer/archiving with iPods for data backup

How to use Sensors

ASOF Vernier Probe Kit.

Throughout probe/sensor training with both teachers (at Alyeska) and with students during the field experience, many questions about the Vernier Probe Kit were asked. The following Frequently Asked Questions (FAQs) were posted on the website for the different probes.

CO₂ Gas sensor

The CO₂ Gas sensor measures carbon dioxide levels in the range of 0 to 100,000 ppm. It has two settings: low range (0 - 10,000 ppm) and high range (0 - 100,000 ppm). This probe is great for measuring changes in CO₂ levels during plant photosynthesis and respiration. With this sensor, you can easily monitor changes in CO₂ levels occurring in respiration of organisms from crickets to humans! The CO₂ gas sensor is easily calibrated using a calibration button.

Q: How does this sensor work?

A: The CO₂ Gas sensor measures gaseous carbon dioxide levels in the range of 0 to 5000 ppm by monitoring the amount of infrared radiation absorbed by carbon dioxide molecules. The sensor uses a hot metal filament as an infrared source to generate infrared radiation (IR). The IR source is located at one end of the sensor's shaft. At the other end of the shaft is an infrared sensor that measures how much radiation gets through the sample without being absorbed by the carbon dioxide molecules. The detector measures infrared radiation absorbed in the narrow band centered at 4260 nm. The greater the concentration of the absorbing gas in the sampling tube, the less radiation will make it from the source through the sensor tube to the IR detector. The temperature increase in the infrared sensor produces a voltage that is amplified and read by the software.

Q: Are there any special needs for power for the CO₂ Gas sensor?

A: The CO₂ Gas sensor needs to be powered during reading. An additional power supply has been provided. Also, provide sufficient time for the CO₂ Gas sensor to warm up and stabilize.

Q: Is there a temperature range at which the CO₂ Gas sensor is most accurate?

A: The CO₂ Gas sensor is designed to operate between 20°C and 30°C. The CO₂ Gas sensor can be used outside of this temperature range; however, you should be aware that there will be a loss in accuracy of readings. This does not prohibit taking readings using incubation temperatures or outdoor readings at temperatures warmer or colder than the 20 to 30°C range. Allow enough time for your CO₂ Gas sensor to stabilize at the desired operating temperatures.



Q: Do I need to calibrate this sensor?

A: You should not have to perform a new calibration when using the CO₂ Gas sensor in the classroom. The sensor has been set to match a stored calibration before shipping it. You can simply use the appropriate calibration file that is stored in your data-collection program. If you do find that you need to reset your CO₂ Gas sensor, it can be reset using one known CO₂ level. Note: This calibration method is different than the usual two-point calibration performed using other sensors. To reset the CO₂ Gas sensor in units of parts per million (ppm) you will need to place the sensor in the 250 mL collection bottle (included with your sensor) in the air outside your building long enough to ensure that its contents are replaced with fresh air. The calibration will be based on this sample having a carbon dioxide concentration of about 400 ppm. While still outdoors (with the slit rubber stopper on the sensor tube of the CO₂ Gas sensor), insert the stopper into the gas-sampling bottle containing fresh outside air. Do this by holding the stopper, not the probe box. You can now take the bottle and sensor to the location where the calibration is to be done (either outside or back in the classroom). Connect the CO₂ Gas sensor to the interface. Start the data-collection program. Let the sensor warm up by collecting data for at least 90 seconds. You can monitor the CO₂ reading by simply observing the live display on the computer data-collection software.

When the CO₂ Gas sensor has warmed up (readings should have stabilized), use a paper clip or the point of a mechanical pencil to press down the calibration button. Release the button immediately after the Red LED blinks rapidly three times. After about 30 seconds, the reading should stabilize at a value of approximately 400 ppm (± 50 ppm). If the reading is significantly lower or higher than 400 ppm, simply press the button again to repeat the process.

Q: Is there an online User Guide?

A: Available at www2.vernier.com/booklets/co2-bta.pdf

Infrared (IR) Thermometer

The Infrared thermometer is a non-contact, fast responding temperature-measuring device. The sensor works by measuring the infrared radiation emitted by objects. For most objects, you simply point the sensor at the object and read its temperatures.

Q: Do I need to calibrate this sensor?

A: The Infrared Thermometer is automatically (auto ID) detected and calibrated when connected.

Q: Is the laser pointer dangerous?

A: This sensor contains a laser that can be turned on and off. As with any laser, caution must be exercised when using the sensor. The sensor emits laser radiation, and therefore, should not be pointed at the eye. Pay special attention to the location of the aperture, which is located next to the sensing element. Pay special attention to the location of the aperture, which is located next to the sensing element. Direct eye contact with the laser beam may cause serious injury. Students should be reminded that this is not a toy, and it should be kept out of reach of children.

Q: Is there a way to switch from Celsius to Fahrenheit readings?

A: The sensor reading will appear in °C. When connected to a data-collection interface, data can be collected in other units, e.g.,

°F and °K. If you are using Logger Pro software, an alternative is to open an experiment file in the Logger Pro Probes & Sensors folder. The Infrared Thermometer folder contains other experiment files and calibrations, including one for temperature in °F (Fahrenheit), and another in K (Kelvin).



Q: Is there an online User Guide?

A: Available at www2.vernier.com/booklets/irt-bta.pdf

Light sensor

The light sensor approximates the human eye in spectral response and can be used over three different illumination ranges and measurements of light intensity in the environment.

Q: How does this sensor work?

A: The sensor uses a Hamamatsu S1133 silicon photodiode. It produces a voltage which is proportional to light intensity. The spectral response approximates the response of the human eye as shown in this diagram. The switch on the box is used to select the range. If the reading from the sensor reaches the maximum for the selected ranges, you need to switch to a less sensitive range. If the reading is very small or 0, you need to select a more sensitive range.

Q: How do you change light ranges?

A: The switch box is used to select the range from 0-600 lux or 0-6000 lux or 0-150,000 lux. The 0-600 lux range is the most sensitive and is useful at low levels of illumination. The 0-6000 lux range is good for indoor light levels. The 0-150,000 lux range is used for measurements in sunlight. The 0-600 lux range is the most sensitive and is useful at low levels of illumination. The 0-6000 lux range is good for indoor light levels. The 0-150,000 lux range is used for measurements in sunlight.

Q: Is there an online User Guide?

A: Available at www2.vernier.com/booklets/lis-bta.pdf

O₂ Gas sensor

The O₂ Gas sensor measures oxygen concentration in air. The O₂ Gas sensor requires no special preparation or calibration-just plug it into your interface and it is ready to take readings. Included with the O₂ Gas Sensor is a 250-mL bottle to be used as a respiration chamber for studying plants and insects, or rusting of iron.

Q: How does this sensor work?

A: The O₂ Gas sensor is used to monitor gaseous oxygen. The O₂ Gas sensor measures the oxygen concentration in the range of 0 to 27% using an electrochemical cell. The cell contains a lead anode and a gold cathode immersed in an electrolyte. When oxygen molecules enter the cell, they get electrochemically reduced at the gold cathode. This electrochemical reaction generates a current that is proportional to the oxygen concentration between the electrodes. The current is measured across a resistance to generate a small voltage output.

Q: Do I need to calibrate this sensor?

A: For many measurements, it will not be necessary to calibrate the O₂ Gas sensor. The sensor has been set to match a stored calibration before shipping it. You can simply use the appropriate calibration file, which is stored in your data-collection program. For more accurate measurements, the sensor can be calibrated at 0 and 20.9% oxygen. Follow the normal 2-point calibration procedure. For the first point, push and hold the zero button located on the top of the sensor. Enter a value of 0 for this reading. Release the button and take a second reading. Enter a value of 20.9% oxygen or a corrected value from the table below. Once finished, the sensor should now read 20.9 (or the value entered from the table below) while resting in the gas-sampling bottle. To calibrate in parts per thousand, multiply the second value by 10 (for example, you would enter 209 instead of 20.9).

Q: Is there an online User Guide?

A: Available at www2.vernier.com/booklets/o2-bta.pdf

pH sensor

pH is a measurement of the balance between hydroxide and hydronium ion in a solution. The pH sensor measures ranges from 0 to 14 with 7 being neutral and anything above 7 being basic and any value below 7 being acidic.

Q: Do I need to calibrate this sensor?

A: You should not have to perform a new calibration when using the pH sensor for most experiments in the classroom. The sensor has been set to match a stored calibration before shipping it. You can simply use the appropriate calibration file that is stored in your data-collection program from Vernier. If it should not be necessary to calibrate the pH sensor, you can use the 2-point calibration option of the Vernier data-collection program. Rinse the tip of the electrode in distilled water. Place the electrode into one of the buffer solutions (e.g., pH 4). When the voltage reading displayed on the computer screen stabilizes, enter a pH value, "4". For the next calibration point, rinse the electrode and place it into a second buffer solution (e.g., pH 7). When the displayed voltage stabilizes, enter a pH value, "7". Rinse the electrode with distilled water and place it in the sample to be measured. In order to do a calibration of the pH Sensor, or to confirm that a saved pH calibration is accurate, you need to have a supply of pH buffer solutions that cover the range of pH values you will be measuring. We recommend buffer solutions of pH 4, 7, or 10.

Q: How do I best store the pH sensor?

A: Long-term storage (more than 24 hours): Store the electrode in a buffer pH-4/KCl storage solution in the storage bottle. The pH Electrode is shipped in this solution. Vernier sells 500 mL bottles of replacement pH Storage Solution.

Q: Is there an online User Guide?

A: Available at www2.vernier.com/booklets/ph-bta.pdf

Salinity sensor

This sensor easily and accurately measures the total-dissolved salt content in water. Salinity is an important measurement in seawater or in estuaries where freshwater from rivers and streams mixes with salty ocean water. The salinity level in seawater is fairly constant, at about 35 ppt (35,000 mg/L), while brackish estuaries may have salinity levels between 1 and 10 ppt. The Vernier Salinity Sensor has a range of 0 to 50 ppt.

Q: What does the salinity sensor measure?

A: The salinity sensor measures the total-dissolved salt content in water. The Vernier Salinity Sensor has a range of 0 to 50 ppt. This means it can be used to measure water with a wide variety of salinities, from freshwater to ocean water, and even hyper-saline environments. The sensor measures the ability of a solution to conduct an electric current between two electrodes.

Q: Are there any special needs while storing the sensor?

A: When you have finished using the Salinity Sensor, simply rinse it off with distilled water and blot it dry using a paper towel or lab wipe. The probe can then be stored dry.

Q: Do I need to calibrate this sensor?

A: In most cases, the answer is no. Each Salinity sensor is individually calibrated before it is shipped. This calibration is stored on the sensor and will be used by default. If you wish to calibrate the Salinity Sensor yourself, you may do so using a two-point calibration. Simply perform the first calibration point with the probe out of any liquid or solution (e.g., in the air). A very small voltage reading will be displayed on the computer. Place the Salinity Sensor into a standard solution (solution of known concentration) for the second calibration point. Be sure the entire elongated hole with the electrode surfaces is submerged in the solution. Wait for the displayed voltage to stabilize. Enter the value of the standard solution (e.g., 35 ppt).

Q: How do salinity readings change based on temperature?

A: The Salinity Sensor is automatically temperature compensated between temperatures of 5 and 35°C. Readings are automatically referenced to a conductivity value at 25°C; therefore, the Salinity Sensor will give the same conductivity reading in a solution that is at 15°C as it would if the same solution were warmed to 25°C. This means you can calibrate your probe in the lab, and then use these stored calibrations to take readings in colder (or warmer) water in a lake or stream. If the probe was not temperature compensated, you would notice a change in the conductivity reading as temperature changed, even though the actual ion concentration did not change.

Q: Is there an online User Guide?

A: Available at <http://www2.vernier.com/booklets/sal-bta.pdf>

Stainless Steel Temperature sensor

The stainless steel temperature probe is a rugged temperature sensor that is frequently used in a variety of experiments and has a temperature range of -40 to 135 degrees C. In general the temperature probe does not need to be calibrated and is resistant to corrosion.

Q: How durable is this sensor?

A: This is a very durable sensor. It can be used in chemicals, boiling water, and weather studies. However, the black molded plastic handle is not waterproof and should not be submerged.

Q: Do I need to calibrate this sensor?

A: In most cases, the Stainless Steel Temperature Probe will never need to be calibrated. It is calibrated extremely well before it ships. However, if the need arises to calibrate the sensor, the sensor can be custom-calibrated. The process of calibrating a Stainless Steel Temperature probe is different than the process for most other sensors. One reason is that this probe uses a thermistor, which has a non-linear response, and you need to calibrate it at three different temperatures, as opposed to a two-point calibration.

Q: Is there an online User Guide?

A: Available at www2.vernier.com/booklets/tmp-bta.pdf

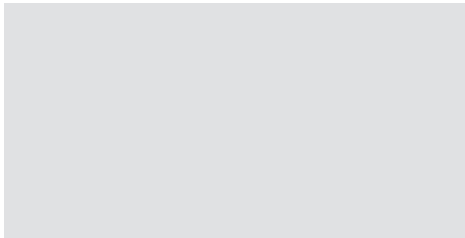
Q: Is there an online User Guide?

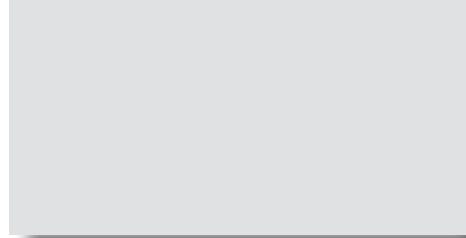
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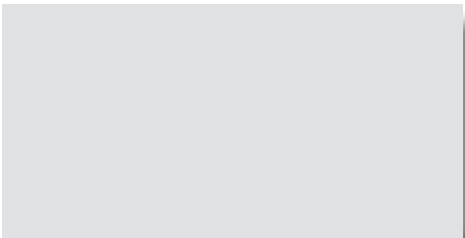
Appendix II

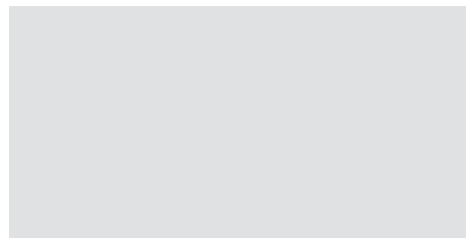
Storytelling Tools

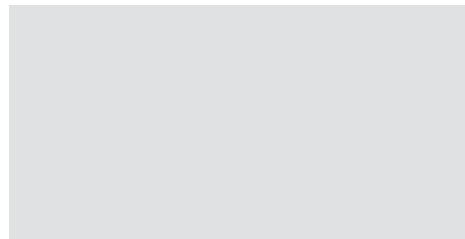
Storyboard

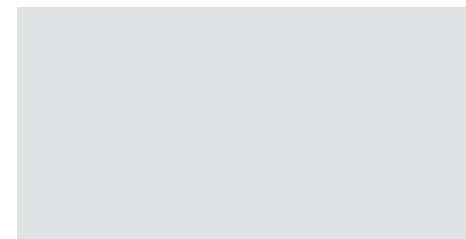














My Story

STEP 1: Create a storyboard

Hint: Must have a beginning, middle, end, PLUS a problem / solution

Notes: _____

STEP 2: Plan scenes (do you need props, other media?)

Notes: _____

STEP 3: Shoot video / still pictures

Notes: _____

STEP 4: Edit on I-Movie

Notes: _____

STEP 5: Create & insert music

Notes: _____

STEP 6: Present to class

What actions did I encourage for the audience: _____

Storytelling Rubric

<i>Concept</i>	<i>Advanced</i>	<i>Proficient</i>	<i>Developing</i>
Personal: Emotion & Intellectual	• Teaches others how to use emotion to support the message. • Content causes audience to want to be active in the cause.	• Story caused emotional response (laughing, crying, reflecting, surprise). • Content showed depth of issue(s) presented.	• Story caused emotional response that was predictable. • Content was factual and accurate.
Social: Perspective, Creativity	• Teaches others how to use the “voice” of the story to present different ideas. • Story includes creative ideas and techniques that others will want to use.	• The “voice” of the story is unique from first person, or third person. • Story includes some unique ways of presenting the issues.	• Story is predictable, from one person’s point of view. • Story includes something unique.
Technical: Still, motion, transitions, filters, special effects	• Teaches others how to use a tripod, take clear, focused pictures. • Teaches others how to use special effects to make the story better, without distracting from the message.	• Photography enhances the message, with clear focus and no shaking. • Filters and special effects are not obvious, but help tell the story in creative ways.	• Photography is focused and clear. • Transitions are smooth and consistent. • Filters and special effects don’t distract from the message.
Project Management: storyboard, timeline, shooting, editing, final product production	• Teaches others how to set and meet goals. • Models effective use of a storyboard. • Final product is done when originally planned.	• A storyboard was used to pre-plan the scenes and shoots. • Editing took less time than half the total project. • Final product is completed on time or prior to original deadline.	• A storyboard was drawn up. • The timeline was used most of the time.
Impact: Clear message, audience reaction	• The message is repeated by others. • The audience reacts in a way that is intended.	• The message is clear. • The audience has a reaction.	• A message is attempted, but unclear. • Some of the audience responds.

Story-Telling Elements:

- Plot
- Economy
- Soundtrack
- Gift of Your Voice
- Point of View
- Dramatic
- Emotional
- Pacing

Appendix III

Do It Yourself (DIY)

Field Activities

Example for DIY (Do It Yourself): Albedo and cloud cover

(<http://onrdiy.concord.org/activities/58>)

Introduction/Discovery Question

What happens when the earth's ice and snow cover melts?

Prediction

What happens when the earth's ice and snow cover melts?

When sunlight strikes the earth, several things can happen to it. A fixed percentage is absorbed by the earth's surface and a fixed percentage is reflected. In reality, this percentage has not been the same over geologic time.

The word albedo is used to describe how reflective a surface is. It ranges from 0, representing total absorption, to 100, representing total reflection. The average albedo of the earth's surface is about 40%, but this average is affected by the proportions of different surfaces—trees, grasses, bare earth, snow, water—because each has a different albedo.



Would the earth's average temperature be higher or lower if the average albedo decreased? Explain.

Here are some approximate values of albedo. Think of natural or human-caused events that would change the albedo of the planet.

evergreen trees: 9%

broadleaf trees: 13%

grasses: 20%

farmland: 15%

sand: 25%

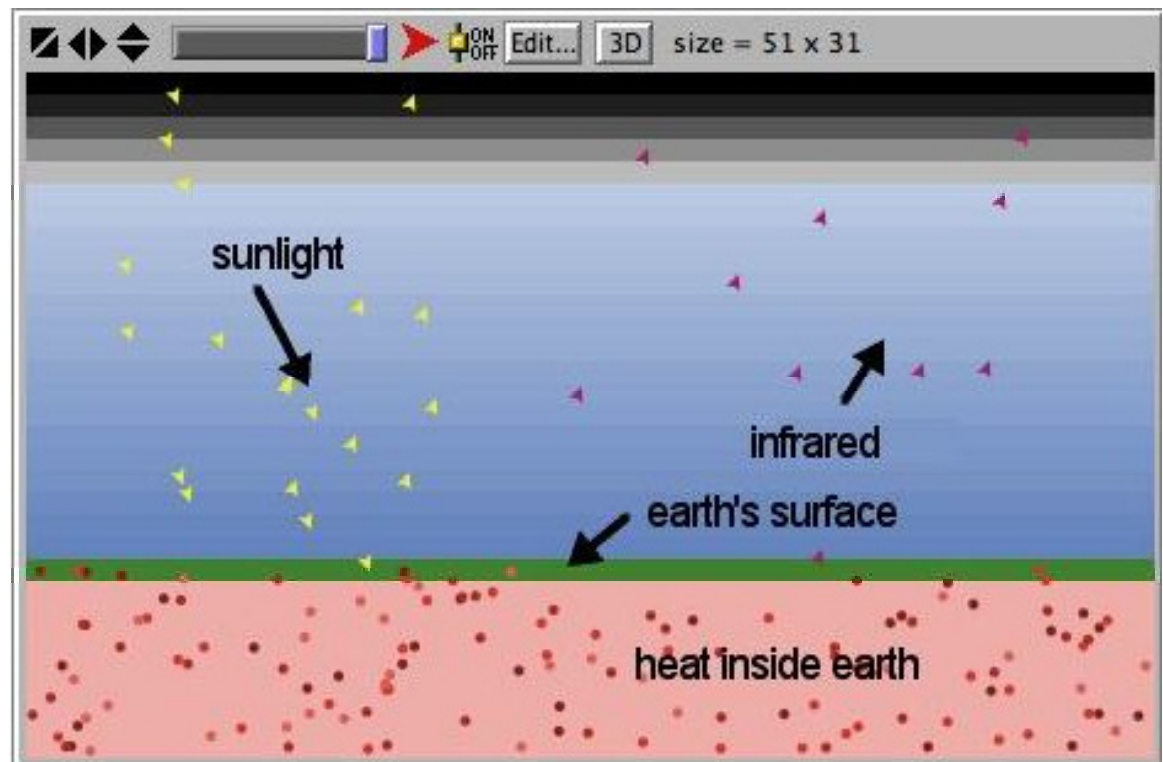
urban areas: 10%

ocean: 5%

snow / ice cover: 90%

Explain why the earth's albedo might have changed during the ice ages.

Collect Data



Here is a model of how the earth's atmosphere and surface affect the energy balance between incoming and outgoing radiation.

In this model, the earth is pink, the earth's surface is green, the atmosphere is blue, and outer space is black. Yellow arrows represent sunlight (solar radiation). Red arrows represent heat energy (infrared radiation) emitted by the earth. Red dots represent heat energy trapped in the earth.

1. To run the model, always click the **SETUP** button first, and then click the **GO** button. You can pause the model by clicking the **GO** button again.
2. Let the model run until the temperature stops changing very much. At this point the energy arriving on the earth is roughly equal to the energy leaving the earth.
3. Note the **ALBEDO** slider, which ranges from 0 (0) to 1 (100). Change the albedo. What does it do to the earth's surface in the model?
4. Try different values of albedo, including 0 and 1. Run the model long enough for the temperature to stabilize. Record the average temperature for different values of albedo.
5. Set the albedo to 0.4 and reset the model. Try the **ADD CLOUD** button. What effects do clouds have on the incoming sunlight and the outgoing infrared?
6. Try different amounts of clouds and record how the temperature changes. After each change, run the model until the temperature stabilizes.

Further Investigation

For more information on NetLogo, go to the NetLogo Home Page. (<http://ccl.northwestern.edu/netlogo/>) You can download NetLogo and build your own models or modify the ones in the Models Library.

Other Do It Yourself Activities Available on the website ***

- 1) Mixing Different Temperature Water - Temperature Sensor – Carolyn Staudt
- 2) Does exercise affect your body temperature? – Temperature Sensor – Ayme Johnson
- 3) CO₂ vs O₂ with plants and yeast – CO₂ sensor – Steve Grajewski
- 4) CO₂ levels in 3 environments – CO₂ sensor – Sheryl Salasky
- 5) Transpiration – Relative Humidity Sensor – Carolyn Staudt
- 6) Water Cycle – Relative Humidity Sensor – Carolyn Staudt
- 7) Explore ocean salinity – Salinity Sensor – Ed Hazzard
- 8) Blubber – Temperature Sensor - Carolyn Staudt
- 9) Explore estuary surface temperature – Temperature Sensor - Ed Hazzard
- 10) Greenhouse Effect - Temperature Sensor - Carolyn Staudt
- 11) Ocean Surface Temperature – Temperature Sensor - Ed Hazzard
- 12) Salinity – Salinity Sensor – Ed Hazzard
- 13) Water temperature and density – Temperature Sensor - Ed Hazzard
- 14) Albedo and cloud cover – NetLogo Model - Carolyn Staudt
- 15) Radiant energy flow – NetLogo Model - Carolyn Staudt
- 16) Tracking a Storm - Temperature Sensor - Carolyn Staudt
- 17) Melting ice - Temperature Sensor - Carolyn Staudt
- 18) Collision heat model – NetLogo Model - Carolyn Staudt
- 19) Respiratory rate during exercise - Temperature Sensor - Carolyn Staudt
- 20) Algae on the move – NetLogo Model - Carolyn Staudt
- 21) Build a Greenhouse - Temperature Sensor - Carolyn Staudt
- 22) Heat propagation – Molecular Workbench Model - Carolyn Staudt
- 23) Body temperature: Thermoregulation - Temperature Sensor - Carolyn Staudt

Appendix IV

Assessments

ASOF Pre and Post Video Interview Student Questions

- Tell us how you came to live in “Anderson, Anchorage, Whittier...”
- Describe the lifestyle you’d like to have when you grow up?
- What professions would work for the lifestyle you just described?
- If you had a whole day to do whatever you wanted, what would you do?
- If you were hiking around Denali and found a mysterious object that no one has ever seen before, what would you do with the discovery?
- Pretend you just found out that you are on a deserted island, what would you do? (If they stop with survival responses, fire, food, shelter... then ask: then what would you do?)
- What do you think is the greatest discovery of all time and why? (if they are stumped, ask the next question and then go back to this one.)
- Describe the difference between invention and discovery.
- Describe a current issue in science.
- Tell us about a current ethical debate behind that issue.
- Tell me what you know about global warming.
- Describe the life of a scientist.
- Do you know or have you ever met any scientists? If yes, what do they do?
- Who are the people who inspire you and why? What do they do for a living. (If you didn’t already get that in an earlier answer

LAB ASSESSMENT

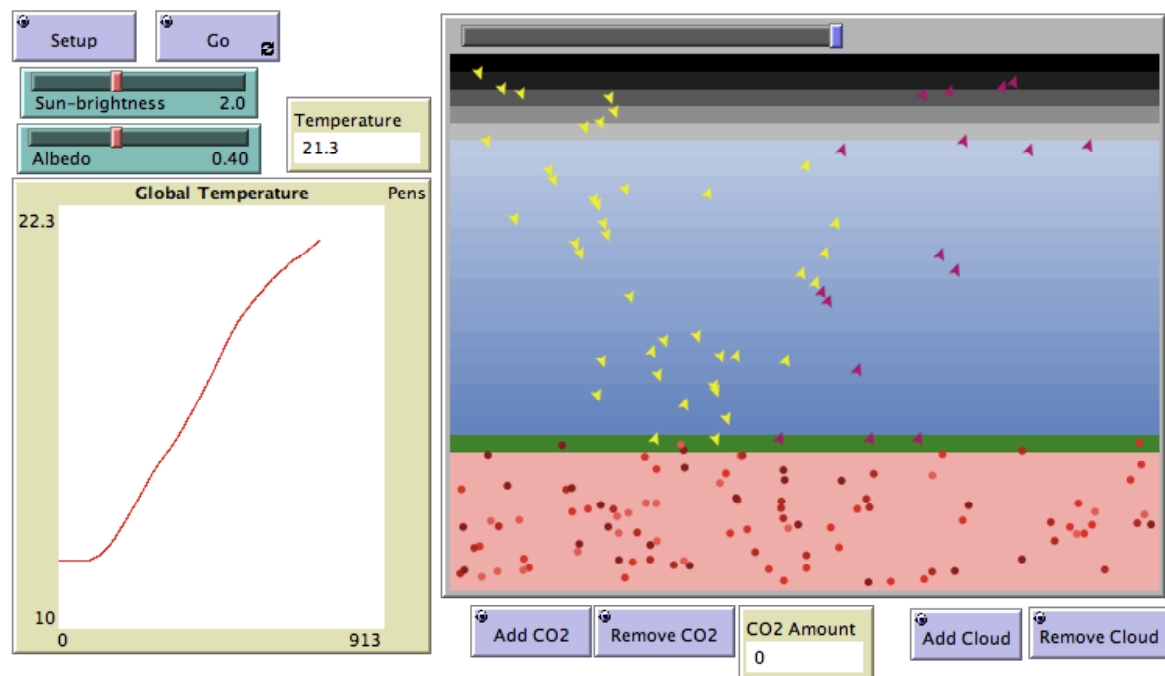
SCIENTIFIC KNOWLEDGE IS DURABLE YET TENTATIVE.

- How have scientists throughout history thought about global warming?
- As scientists obtained more information, how did the ideas about global warming change?
- Describe an example of how an idea in global warming has changed when new information was found to be reliable.

- Describe an example of how scientists are strict about the information they get.

EMPIRICAL EVIDENCE IS USED TO SUPPORT IDEAS IN SCIENCE.

- Describe an observation where you saw, heard or touched something.
- Describe what you had to measure in this lab, and how you measured it.
- Describe the lab in a way that someone else would understand it.
- Describe your observations of your lab based on your senses and not inferences.
- What kind of conclusions can you draw from your observations?
- Describe your observations without making any personal judgments.



Model created with the [NetLogo](#) programming language.

SCIENCE IS A CREATIVE ENDEAVOR.

- What did you think about when you did your lab?
- What patterns did you see as you gathered data?
- What different conclusions could you come up with based on your results, and which one makes the most sense to you?

- Why does the conclusion you chose make sense compared to the other options?

Edited into Inquiry Format.

Taken in part from: Thinking Like Scientists: Using the Nature of Science as a Metacognitive Tool

Erin E. Peters, NBCT

Why is the teaching of the Nature of Science Important?

Erin E. Peters, NBCT

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ALASKA SCIENTISTS OF THE FUTURE

ASSESSMENT TOOL

Inquiry Based Units for Science Content

	Advanced	Proficient	Developing	Emerging
Questions	Values and enjoys asking scientific questions that lead to <i>bigger picture</i> questions. Processes abstract ideas, and applies to project.	Asks questions that are scientifically oriented. Considers abstract ideas and begins to make connections to projects.	Asks questions and attempts ones that are scientifically oriented.	Begins to ask questions.
Observe	Teaches others to observe and see details and patterns. Detects and describes sequences and events, processes, and identifies relationships. Clearly explains connections to previous ideas.	Observes details and patterns. Describes sequences and events, notice processes, similarities and differences. Makes connections to previous ideas.	Begins to see details and patterns. Begins to detect sequences and events, notice changes, similarities and differences. Makes a connection to a previous idea.	Practices observing. Practices looking for similarities and differences. Attempts to make a connection to a previous idea.

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ASSESSMENT TOOL

Explore	Accepts and encourages others to accept an <i>invitation to learn</i>. Exhibits and inspires authentic curiosity. Teaches others to ponder observations. Leads the exploration process.	Accepts an <i>invitation to learn</i>. Exhibits curiosity and ponders observations. Engages in the exploration process.	Begins to ponder observations. Begins to engage in the exploration process.	Begins to show curiosity toward observations. Is aware of the exploration process.
Investigate, Experiment	Teaches others how to design investigations to try out ideas. Models how to handle materials with care, observing, measuring and recording data. Models how to develop and evaluate and communicate explanations. Presents ways to verify, extend, or discard ideas.	Designs investigations (experiments) to try out ideas. Handles materials with care, observing, measuring and recording data. Develops and evaluates explanations. Plans ways to verify, extend, or discard ideas.	Practices how to design investigations to try out ideas. Practices handling materials with care, observing, measuring and recording data. Develops explanations. Begins to plan ways to verify, extend, or discard ideas.	Begins to design investigations to try out ideas. Knows the process to handle materials with care. Practices observing, measuring recording data. Begins to develop explanations.

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ASSESSMENT TOOL

For Teachers:

LESS EMPHASIS ON	MORE EMPHASIS
Activities that demonstrate and verify science content	Activities that investigate and analyze science questions
Investigations confined to one class period	Investigations over extended periods of time
Process skills out of context	Process skills in context
Emphasis on individual process skills such as observations or inference	Using multiple process skills—manipulation, cognitive, procedural
Getting an answer	Using evidence and strategies for developing or revising an explanation
Science as exploration and experiment	Science as argument and explanation
Providing answers to questions about science content	Communicating science explanations
Individuals and groups of students analyzing and synthesizing data without defending a conclusion	Groups of students often analyzing and synthesizing data after defending conclusions
Doing few investigations in order to leave time to cover large amounts of content	Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content
Concluding inquiries with the result of the experiment	Applying the results of experiments to scientific arguments and explanations
Management of materials and equipment	Management of ideas and information
Private communication of student ideas and conclusions to teacher	Public communication of student ideas and work to classmates

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ASSESSMENT TOOL

Reflect Explore, Expand	Teaches others to create assessment indicators to assess their work and products. Presents research findings and identifies areas of improvement and strength. Presents reflections on their work with peers, adults and experts.	Creates assessment indicators to assess their own work and products. Identifies and reports research findings. Identifies areas of improvement and strength. Reflects on their work and work with peers, and adults.	With assistance, creates assessment indicators to assess their own work and products. Identifies research findings. Identifies strengths. Reflects on their work and occasionally the work of others.	Attempts to evaluate work and products. Attempts to identify and report research findings. Attempts to identify strengths. Begins to reflect on their work with peers.
Synthesize, Create	Uses and seeks evidence to justify their own statements as well as those of others. Can explain the process used to sort out information and decisions of what is important. Presents revisions to explanations, and shows the consideration of new ideas as knowledge was gained. Presents explanations based on knowledge from research and investigations.	Uses and seeks evidence to justify their own statements. Sorts out information and decides what is important. Willing to revise explanations and consider new ideas as they gain knowledge. Offers explanations based on knowledge from research and investigations.	Uses evidence to justify their statements. Sorts out information and attempts to decide what is important. Willing to consider new ideas as they gain knowledge. Attempts explanations based on knowledge from research and investigations.	Tries to use evidence to justify their statements. Sorts out information. With assistance, tries to consider new ideas. Attempts explanations loosely based on gathered knowledge.

ALASKA SCIENTISTS OF THE FUTURE

ASSESSMENT TOOL

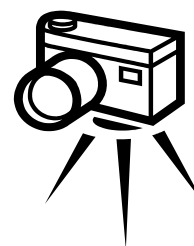
Technology	Relies on technology to enhance the gathering and manipulation of data. Can present, explain or defend this reliance.	Relies on technology to enhance the gathering and manipulation of data.	Has used technology to enhance the gathering of data and manipulation of data.	Begins to use technology to enhance the gathering of data..
Scientific Method	Clarifies the question, method, controls, and variables. Convincingly presents a powerful argument, using evidence and applied logic for proposed explanations. Can teach the purpose and need for revision of methods and explanations. Teaches others to write and design procedures.	Clarifies the question, the method, controls, and begins to explain variables. Uses evidence, and applies logic to construct an argument for proposed explanations. Revises methods and explanations. Writes and designs procedures.	Clarifies the question and the method and begins to explain controls and variables. Gathers evidence and attempts to apply logic to construct an argument for proposed explanations. Has revised others method and explanation. Writes procedures.	Clarifies the question and begins to explain the method, controls, and variables. Gathers evidence and attempts to construct an argument for proposed explanations. Attempts to revise a method and explanation. Begins to design procedures.

Appendix V

Boot Room

HISTORY:

The “boot room” concept comes from our storytelling camp we held in England last summer. This is a room where people take off their boots before entering a house. It was quiet, and became the space we set up a video camera for personal assessments through video tape of what was happening. Students would go into the room and record their thoughts, anytime, during the camp. The only ones who watched this was the coordinators, so we could evaluate the feedback and use it to improve next time. Since no one was running the camera but the students, when they were ready, it became a very powerful tool for honest feedback.



SET UP:

- 1) Find a small, quite, private room you can use for video recording.
- 2) Designate a video camera on a tripod to stay in the room.
- 3) Post the “Taping... Do not disturb / Personal Testimonies Enter Here” sign
- 4) Use the sign-up for access and approval
- 5) Post the “Look Here” board just above the camera.
- 6) Post the “Instructions” on the tripod.
- 7) Have a chair positioned to be covered by the camera’s view
- 8) Post the “Leading Questions” above the camera, on the wall.

USE:

- 1) Explain to the students what the “Boot Room” is intended for. Remind them about responsible use of equipment and appropriate interview language and content. Help them feel comfortable that what they say is confidential and will only be used by the facilitators for evaluation of how they might improve the program. (Make sure there is enough tape in the camera.)
- 2) Have a responsible adult with the key to the room check kids in/out.
- 3) Students may stay as long or little as they like, recording their testimonies as they feel comfortable and ready, anytime.

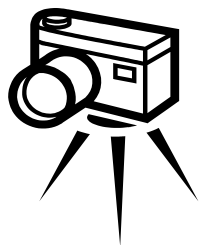
FINISHING UP:

- 1) Send all video tapes to: (designated person) Please complete with return form, so we know who it is from.
- 2) If you would like a dvd copy, please indicate on the form.

BOOT ROOM LEADING QUESTIONS

(Post on wall behind & just above camera)

- 1) What is your first & last name, and position?
- 2) What is your greatest hope and/or fear for this project?
- 3) What activity / lesson do you feel was the most helpful during our training and why?
- 4) Do you believe, through these activities planned, that we will be able to find evidence of what causes students to want to become Scientists? Why?
- 5) What comments / suggestions can you give the planning team?
- 6) Other thoughts or comments?

**VIDEO CAMERA INSTRUCTIONS**

(Post on wall behind & just above camera)

- 1) Be sure you have a new tape for camera and the camera is on (not recording yet).
- 2) Review questions and think about your answers.
- 3) When you are ready, hit "record" and sit comfortably in the stool positioned for the camera view.
- 4) Answer the questions. Take as long as you would like. Be real, honest, and specific.
- 5) Turn off the camera when done.
- 6) Take out the tape, label it and give to coordinator.
- 7) Sign out and turn post over so the room is ready for the next person.
- 8) What activity / lesson do you feel was the most helpful during our training and why?

Appendix VI

National Science Standards Grades 5-8

Science as Inquiry:

CONTENT STANDARD A:

As a result of activities in grades 5-8, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science:

CONTENT STANDARD B:

As a result of their activities in grades 5-8, all students should develop an understanding of

- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

Life Science:

CONTENT STANDARD C:

As a result of their activities in grades 5-8, all students should develop understanding of

- Structure and function in living systems
- Reproduction and heredity
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

Earth and Space Science:

CONTENT STANDARD D:

As a result of their activities in grades 5-8, all students should develop an understanding of

- Structure of the earth system
- Earth's history
- Earth in the solar system

Science and Technology:

CONTENT STANDARD E:

As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives:

CONTENT STANDARD F:

As a result of activities in grades 5-8, all students should develop understanding of

- Personal health
- Populations, resources, and environments
- Natural hazards
- Risks and benefits
- Science and technology in society

History and Nature of Science:

CONTENT STANDARD G:

As a result of activities in grades 5-8, all students should develop understanding of

- Science as a human endeavor
- Nature of science
- History of science

National Science

Content Standards (Grades 5-8)

<http://books.nap.edu/html/nses/html/6d.html#si>

National Science Standards Grades 9-12

Science as Inquiry:

CONTENT STANDARD A:

As a result of activities in grades 9-12, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science:

CONTENT STANDARD B:

As a result of their activities in grades 9-12, all students should develop an understanding of

- Structure of atoms
- Structure and properties of matter
- Chemical reactions
- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter

Life Science:

CONTENT STANDARD C:

As a result of their activities in grades 9-12, all students should develop understanding of

- The cell
- Molecular basis of heredity
- Biological evolution
- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

Earth and Space Science:

CONTENT STANDARD D:

As a result of their activities in grades 9-12, all students should develop an understanding of

- Energy in the earth system
- Geochemical cycles
- Origin and evolution of the earth system
- Origin and evolution of the universe

Science and Technology:

CONTENT STANDARD E:

As a result of activities in grades 9-12, all students should develop

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives:

CONTENT STANDARD F:

As a result of activities in grades 9-12, all students should develop understanding of

- Personal and community health
- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science:

CONTENT STANDARD G:

As a result of activities in grades 9-12, all students should develop understanding of

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

National Science

Content Standards (Grades 9-12)

<http://books.nap.edu/html/nses/html/6e.html>

Alaska State Science Standards Grades 6-8

Science as Inquiry and Process:

CONTENT STANDARD A1:

SA Students develop an understanding of the processes and applications of scientific inquiry.

SA1 Students develop an understanding of the processes of science used to investigate problems, design and conduct repeatable scientific investigations, and defend scientific arguments.

SA2 Students develop an understanding that the processes of science require integrity, logical reasoning, skepticism, openness, communication, and peer review.

SA3 Students develop an understanding that culture, local knowledge, history, and interaction with the environment contribute to the development of scientific knowledge, and that local applications provide opportunity for understanding scientific concepts and global issues.

Physical Science:

CONTENT STANDARD B1:

SB Students develop an understanding of the concepts, models, theories, universal principles, and facts that explain the physical world.

SB1 Students develop an understanding of the characteristic properties of matter and the relationship of these properties to their structure and behavior.

SB2 Students develop an understanding that energy appears in different forms, can be transformed from one form to another, can be transferred or moved from one place or system to another, may be unavailable for use, and is ultimately conserved.

SB3 Students develop an understanding of the interactions between matter and energy, including physical, chemical, and nuclear changes, and the effects of these interactions on physical systems.

SB4 Students develop an understanding of motions, forces, their characteristics and relationships, and natural forces and their effects.

Life Science:

CONTENT STANDARD C1:

SC Students develop an understanding of the concepts, models, theories, facts, evidence, systems, and processes of life science.

SC1 Students develop an understanding of how science explains changes in life forms over time, including genetics, heredity, the process of natural selection, and biological evolution.

SC2 Students develop an understanding of the structure, function, behavior, development, life cycles, and diversity of living organisms.

SC3 Students develop an understanding that all organisms are linked

Earth Science:

CONTENT STANDARD D1:

SD Students develop an understanding of the concepts, processes, theories, models, evidence, and systems of earth and space sciences.

SD1 Students develop an understanding of Earth's geochemical cycles.

SD2 Students develop an understanding of the origins, ongoing processes, and forces that shape the structure, composition, and physical history of the Earth.

SD3 Students develop an understanding of the cyclical changes controlled by energy from the sun and by Earth's position and motion in our solar system.

SD4 Students develop an understanding of the theories regarding the evolution of the universe.

Science and Technology:**CONTENT STANDARD E1:**

SE Students develop an understanding of the relationships among science, technology, and society.

SE1 Students develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations, and responses to problems and everyday events.

SE2 Students develop an understanding that solving problems involves different ways of thinking, perspectives, and curiosity that lead to the exploration of multiple paths that are analyzed using scientific, technological, and social merits.

SE3 Students develop an understanding of how scientific discoveries and technological innovations affect and are affected by our lives and cultures.

Cultural, Social, Personal Perspectives, and Science:**CONTENT STANDARD F1:**

SF Students develop an understanding of the dynamic relationships among scientific, cultural, social, and personal perspectives.

SF1 Students develop an understanding of the interrelationships among individuals, cultures, societies, science, and technology.

SF2 Students develop an understanding that some individuals, cultures, and societies use other beliefs and methods in addition to scientific methods to describe and understand the world.

SF3 Students develop an understanding of the importance of recording and validating cultural knowledge.

History and Nature of Science:**CONTENT STANDARD G1:**

SG Students develop an understanding of the history and nature of science.

SG1 Students develop an understanding that historical perspectives of scientific explanations demonstrate that scientific knowledge changes over time, building on prior knowledge.

SG2 Students develop an understanding that the advancement of scientific knowledge embraces innovation and requires empirical evidence, repeatable investigations, logical arguments, and critical review in striving for the best possible explanations of the natural world.

SG3 Students develop an understanding that scientific knowledge is ongoing and subject to change as new evidence becomes available through experimental and/or observational confirmation(s).

SG4 Students develop an understanding that advancements in science depend on curiosity, creativity, imagination, and a broad knowledge base.

Alaska State Science

Content Standards (Grades 6-8)

<http://www.eed.state.ak.us/ContentStandards/>

Alaska State Science Standards Grades 9-12

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Alaska State Science

Content Standards (Grades 9-12)

<http://www.eed.state.ak.us/ContentStandards/>

GLOSSARY

ONR	Office of Naval Research
ASOF	Alaska Scientists of the Future
K-12	Kindergarten thru the 12th Grade
NSES	National Science Education Standards
HTH	Highland Tech High
T.V.	Television
D.V.D.	Digital Video Disc
D.I.Y.	Do it Yourself
I.M.	Instant Messaging
GPS	Global Positioning System
GIS	Geographical Information System
VTC	Video Teleconferencing
CO ₂	Carbon Dioxide
UA _a	Infrared Thermometer
UU _{Vb}	Infrared Thermometer
HOBO	Long Term Thermometers
SCUBA	Self Contained Underwater Breathing Apparatus
KISS	Keep it Simple, Silly
UV	UltraViolet
USGS	United States Geological Survey

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www.futurescientists.org***