

# 21st Century Skills Map

# SCIENCE

DESIGNED IN COOPERATION WITH THE NATIONAL SCIENCE TEACHERS ASSOCIATION (NSTA)

*This 21st Century Skills Map is the result of hundreds of hours of research, development and feedback from educators and business leaders across the nation. The Partnership has issued this map for the core subject of Science. This tool is available at [www.21stcenturyskills.org](http://www.21stcenturyskills.org).*

**The Partnership advocates for the integration of 21st Century Skills into K-12 education so that students can advance their learning in core academic subjects.**

The Partnership has forged alliances with key national organizations that represent the core academic subjects, including Social Studies, English, Math, Science and Geography. As a result of these collaborations, the Partnership has developed this map to illustrate the intersection between 21st Century Skills and Science. The maps will enable educators, administrators and policymakers to gain concrete examples of how 21st Century Skills can be integrated into core subjects.

**A 21st Century Skills**

**B Skill Definition**

**C Interdisciplinary Theme**

**D Sample Student Outcomes/Examples**

An example from the Science 21st Century Skills Map illustrates sample outcomes for teaching Flexibility and Adaptability.

# Science and 21st Century Skills

**In the context of science education, 21st Century Skills offer some new ways of framing what have long been valued approaches in the science classroom and some new ideas for enriching students' investigations with cross-disciplinary modes of learning.**

The inverse is also true. Science contributes its rich traditions of critical and creative thinking, applied technologies, and collaborative work— along with high standards for communication and personal responsibility— to the benefit of 21st Century Skills discussions in all discipline areas. The linkages between the 21st Century and Science skill sets detailed in this map are rooted in the inquiry, process knowledge, experimental design, and scientific habits of mind elements of these traditions, as referenced in the *AAAS Project 2061 Benchmarks for Science Literacy*<sup>1</sup> and the *Atlas of Science Literacy*<sup>2</sup>, and the *National Science Education Standards*<sup>3</sup>, and extrapolated from the practices of scientific research as they are changing in the 21st Century.

Derived from key principles and reflecting emerging best practices, this document is intended to provide snapshot images of what K-12 science education can look like when students are provided opportunities for technology-rich collaboration, creation, contribution, and metacognition in authentic ways that enhance—not replace—robust science content. This document is neither a set of standards nor a comprehensive sequence of activities, but rather a starting point for ideas and discussions that begin with current practice and look forward.

<sup>1</sup> American Association for the Advancement of Science Project 2061. (1993) *Benchmarks for Science Literacy*. New York, NY: Oxford University Press.

<sup>2</sup> American Association for the Advancement of Science Project 2061. (2001, 2007) *Atlas of Science Literacy*, Volumes 1 and 2. Washington, D.C.: AAAS/ National Science Teachers Association. <http://www.project2061.org/publications/atlas/default.htm>

<sup>3</sup> National Research Council. *National Science Education Standards*. (1996). Washington, D.C.: National Academies Press. [http://www.nap.edu/openbook.php?record\\_id=4962](http://www.nap.edu/openbook.php?record_id=4962)

# Creativity and Innovation

# SCIENCE



## 4th Grade

*Science is, by its nature, a creative human endeavor. Scientific and technical innovations are advanced through processes that build on previous knowledge and the application of theory to real world situations. Modern societal and environmental challenges require new and creative scientific and technical approaches, as well as investigations that are more cross-disciplinary.*

**OUTCOME:** Students provide concrete examples of science as a way of thinking that involves both systematic and creative processes that anyone can apply as they ask questions, solve problems, invent things, and develop ideas about the world around them.

**EXAMPLE:** Students examine the ways they use scientific thinking and experimental problem solving processes in their day to day activities such as cooking, gardening, playing strategy games, fixing a bike, or taking care of a pet. For example, as part of a class gardening project, students produce an ongoing podcast or use a wiki to illustrate their processes for determining the ideal conditions for growth, nutrition, and maintenance through the class's design activities.



## 8th Grade

**OUTCOME:** Students are able to describe how science and engineering involve creative processes that include generating and testing ideas, making observations, and formulating explanations; and can apply these processes in their own investigations.

**EXAMPLE:** Student teams design plans for a device that will assist people with disabilities and create 3-D sketches of their device using simple computer aided design software. The class develops criteria for peer review and then teams pass their plans to another team that makes recommendations for refinements to improve the original plans. All teams debrief together on their experience with the engineering/design process and identify the different scientific disciplines they had to draw upon to create their design (biology, physics, engineering, etc.) and how those disciplines interrelate when applied to solving the design problem. Students also discuss what other expertise could be drawn upon to improve their designs including input from people with the disabilities their designs address.



## 12th Grade

**OUTCOME:** Students explain how scientific understanding builds on itself over time, and how advancements in science depend on creative thinking based on the knowledge and innovations of others.

**EXAMPLE:** Students choose a scientific theory and research the history of its development, then use concept mapping or timelining software to diagram previous discoveries, ideas, and technologies upon which the theory was predicated and the different disciplines from which previous knowledge was drawn. Students report on how this theory represented a creative way of approaching this scientific question.





# Critical Thinking and Problem Solving

# SCIENCE



## 4th Grade

*Critical thinking and creative problem solving are the hallmarks of the scientific process. Students can use abilities developed in science to think logically and reasonably about concepts they are learning, and to apply them to their everyday lives. Compelling, and often complex, problems are at the root of many science investigations.*

**OUTCOME:** Students construct their own scientific understanding and develop their scientific process skills by asking scientific questions, designing and conducting investigations, constructing explanations from their observations, and discussing their explanations with others.

**EXAMPLE:** Students plan and conduct experiments to explore the properties (e.g., absorbency, insulation, durability) of various natural and human-designed fabrics and record their findings into a shared class database, wiki, or digital lab notebook. They then use their data to design a suit of clothing for use in a high-performance activity, such as working outdoors in polar regions or competing as an Olympic athlete. Students share design choices with their peers in the form of an advertisement they create to market the product.



## 8th Grade

**OUTCOME:** Students plan and conduct scientific investigations and write detailed explanations based on their evidence. Students compare their explanations to those made by scientists and relate them to their own understandings of the natural and designed worlds.

**EXAMPLE:** Students research how the physical and chemical properties of different natural and human-designed materials affect their decomposition under various conditions. They compare their findings to the material evidence used by scientists to reconstruct the lives of past cultures, as well as create a map of their classroom as a future archeological site (including written descriptions of artifacts) discovered by scientists.



## 12th Grade

**OUTCOME:** Students understand that scientific research and experimentation are guided by fundamental concepts, and that investigations are conducted for different reasons, such as exploring new phenomena, building on previous results, comparing different theories, and addressing problems facing society.

**EXAMPLE:** Student teams use digital libraries and other online resources to research different nanoscale materials, including information about their surface to volume ratio. Using computer-aided design or other digital design/drafting tools, students apply this information by creating designs for houses that use nanomaterials to improve energy efficiency, safety, and durability, and lower costs of construction.





## 4th Grade

*Effective communication is central to scientific research practices. Scientists describe their work so that the research can be duplicated, confirmed, and advanced by others, but also understood by public, non-technical audiences. Scientific thinking is communicated in many different ways including oral, written, mathematical, and graphical representations of ideas and observations.*

**OUTCOME:** Students prepare and interpret a variety of methods for demonstrating understanding and explaining the results of investigations including charts and graphs, diagrams and illustrations, photographic images, and informational and procedural text.

**EXAMPLE:** A class envisions their school as a science museum and creates exhibit signage including text, images, and/or graphs to explain the science around them, within the school and on the grounds (e.g., how the water fountain works, information about school energy usage, or natural history information for identifying tree species around the school).

**OUTCOME:** Students understand that models are simplified representations of real objects and processes, and that models serve as a means to communicate ideas and knowledge about how things work.

**EXAMPLE:** Students seek out a variety of two- and three-dimensional models in their school and home (e.g., a globe, a diagram of the human body, a toy car) and create a table to record each model's type, purpose, and how it varies from a real object or process (e.g., changes in scale, spatial relationships, composition, shape, color, complexity). Student groups discuss why different models are useful for different purposes.



## 8th Grade

**OUTCOME:** Students can identify conventions for writing and speaking scientifically that distinguish scientific communication from other types of expression, and describe reasons behind those differences such as the need in science for precision, detail, and evidence over opinion.

**EXAMPLE:** Students view video samples from a variety of sources of people speaking about a science-related topic (e.g., news reporters, news interviews of science experts, video podcasts of college lectures, segments from public television documentaries, or student-made videos of parents and professionals in their community). Students rate the videos on the degree to which the person sounded scientific, then identify characteristics of speech pattern, word choice, level of detail, and other factors that influenced their perceptions. Students discuss ways that scientific communication differs from other forms of expression, and why those differences might be useful to scientists, then design a card game, board game, or video game that will help teach their peers some of the "rules" of science communication that they've observed.

**OUTCOME:** Students are familiar with the use of computational models as tools to describe and predict real-world phenomena.

**EXAMPLE:** Students interview local scientists (e.g., university researcher, local television meteorologist, medical technician) about the ways in which computer models inform their work. Students create a digital gallery of images from the different models accompanied by audio files of the interviews.



## 12th Grade

**OUTCOME:** Students model the practices of research science by informing others about their work, developing effective explanations, constructing and defending reasoned arguments, and responding appropriately to critical comments about their explanations.

**EXAMPLE:** Students produce a school or district-wide electronic journal to communicate work they are doing in their science classes on a specific unit or topic. Students develop criteria for peer review and critique each other's work, modeling the process for professional journals.

**OUTCOME:** Students can explain why mathematical equations and formulae are used as representations of scientific phenomena and as a means of communicating scientific ideas.

**EXAMPLE:** Student teams design an observational or experimental investigation to explore mathematical relationships commonly applied in science, as appropriate to the level of their math coursework. Students collect and analyze data to support an evidence-based description of their chosen mathematical relationship. For example, to explore change over time equations in their algebra class, students measure the initial circumferences of several balloons filled with helium and several filled by air exhaled from their lungs. Then make additional measurements at regular intervals and plot the changes in size versus time. Students discuss the different rates of change for the two types of balloons and determine the mathematical equations that best describe the results of their change over time investigation.



# Collaboration

# SCIENCE



## 4th Grade

*Science is inherently a collaborative process with 21st Century emphases on interdisciplinary and international research, as well as increasing collaboration between “hard” science and social sciences. A trend toward greater specialization in scientific careers requires researchers to rely on the disciplinary expertise of others as collaborators in their work.*

**OUTCOME:** Students work collaboratively with others, both in small and large groups, in their science classroom.



**EXAMPLE:** Students work with other local schools and community organizations to conduct a backyard species count. The class creates a wiki for collaborators across the community to learn the data protocol, enter their data, and post digital photos. Scientific experts use the wiki to inform their research and help participants identify species. Students present their findings to a local government entity such as a parks commission or urban planning council.



## 8th Grade

**OUTCOME:** Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning.



**EXAMPLE:** Working in collaboration with other classes in the school, students investigate water runoff in their school grounds and use GPS and GIS technologies to create relevant maps. Students are assigned specific interdependent roles based on their interests and talents including background research, data gathering, GPS and GIS use, creating graphics, and communicating findings. Students meet in their investigation teams, and also meet with students in other classes who share their role in the project (i.e., GPS operators from each class meet together to discuss their work).



## 12th Grade

**OUTCOME:** Students collaborate with peers and experts during scientific discourse and appropriately defend arguments using scientific reasoning, logic, and modeling.



**EXAMPLE:** Students participate in a “citizen science” project such as a service learning project, or an environmental issue specific to the community; through which they have the opportunity to work collaboratively with local and remote research scientists, organizations, agencies, and/or universities. Student teams blog about their experiences and how they connect to their classroom learning, then present their research findings to an external audience, such as a science fair, junior academy of science, or local chapter of a scientific professional society.





# Information Literacy

# SCIENCE



## 4th Grade

*Being information literate in the context of science involves assessing the credibility, validity, and reliability of information, including its source and the methods through which the information and related data are derived, in order to critically interpret scientific arguments and the application of science concepts.*

**OUTCOME:** Students are able to locate reliable scientific information in reputable print and electronic resources.



**EXAMPLE:** Students gather menus that contain nutrition facts from local restaurants (including fast food restaurants) and compare the dietetic information with published medical recommendations for daily intake. These comparisons can be drawn from various print media, pamphlets, and websites.



## 8th Grade

**OUTCOME:** Students are able to locate reliable scientific information in reputable reference books, back issues of journals and magazines, on websites, and in computer databases.



**EXAMPLE:** Students compare databases of health-related information (e.g., blood pressure) to determine patterns of distribution and implications of those patterns to different populations. They then take their own blood pressure readings, graphically represent those readings, and compare them to the public databases.



## 12th Grade

**OUTCOME:** Students are able to determine the verifiability of evidence presented in print and electronic resources to evaluate scientific claims.



**EXAMPLE:** Students critique the validity of a health profiling or self-assessment survey available through general public media (e.g., a diet quiz accessed through a fitness magazine website). They then gather scientific research-based resources to assess the accuracy of recommendations made by the tool. Finally, they design their own diet assessment tool making modifications based on their research.



# Media Literacy

# SCIENCE



## 4th Grade

*Media interpretation of scientific information may be different from the interpretation by the scientific community of that same information. Complexities in science do not always convert well into short media messages.*

**OUTCOME:** Students can generate guiding questions to help them evaluate media claims based on evidence rather than simply believing the message as presented.



**EXAMPLE:** From a variety of sources, students collect examples of commercially available products claiming to be “green” or “eco-friendly”. Students discuss the manufacturer’s basis for each claim, and how the meaning of these terms might be different for different groups (e.g., consumers, scientists, medical professionals, environmental regulators); then generate lists of questions that different groups might use to evaluate these claims.



## 8th Grade

**OUTCOME:** Students are able to identify and critique arguments in which the claims are not consistent with the evidence given.

**EXAMPLE:** Student teams research a local environmental issue and prepare editorial essays in the style of a media release, making sure to include evidence of the problem and specific claims they make based on that evidence. Students develop criteria for peer review, then exchange their products and critique each other’s work for consistency of claim and evidence.



## 12th Grade

**OUTCOME:** Students are able to critique claims that people make when they select only data that support the claim, and ignore data that may contradict it.

**EXAMPLE:** Students are provided multiple examples of popular press and news media articles, as well as articles in more scientifically-oriented magazines, about global climate change. Students develop criteria for reviewing the documents including variables of credibility, validity, sources cited, etc. Students evaluate the articles, identifying the claims made in each and the evidence or data that support those claims. Students then rank the articles, as they interpret them, from most to least accurate and scientifically defensible. They are then led in discussion of the rankings and any differences between the popular and more scientific press.





# Information and Communications Technology (ICT) Literacy



## 4th Grade

*Increased computing capacity enables large-scale data analysis, wide-array instrumentation, remote sensing, and advanced scientific modeling. ICT innovations provide new tools for doing science including gathering and analyzing data and communicating results.*

**OUTCOME:** Students can give examples that demonstrate how technology extends the ability of people to observe and interact with the world including how people communicate, gain knowledge, and express ideas.



**EXAMPLE:** Students exchange “biome boxes” with students from various parts of the country. These boxes that contain actual or virtual examples and/or artifacts of living things from their own community are sent to various other schools. They then telecommunicate with students in the schools with whom they exchanged boxes, learning more about those parts of the country and the life in them.



## 8th Grade

**OUTCOME:** Students can articulate how technology is essential to science for such purposes as sample collection and treatment, measurement, data collection and storage, computation, and communication of information.



**EXAMPLE:** Students participate in an established national or international e-science initiative that uses distributed ICT networks to collect scientific data. Students gather and analyze local data or deploy local sensors that contribute to a larger computer-network enabled database. Examples include studies of butterflies, amphibians, bird migrations, local climate variations, and radioastronomy signal analyses.



## 12th Grade

**OUTCOME:** Students can provide examples of how new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research, and how the very availability of new technology itself often sparks scientific advances.

**EXAMPLE:** Students are introduced to a variety of computational models used by scientists to study complex biological interactions, such as population dynamics. Working in teams, students engage in a conceptual design process for a computational model that could be used to investigate a particular ecosystem, creating general schematics that represent different subsystems that would be part of the model, what direct and remotely sensed data inputs would be involved, what external datasets might be useful overlays, what calculations would be run, and what data outputs would be generated.



# Flexibility & Adaptability

*Flexibility and adaptability are valued in science because evidence-based reasoning can change previously held ideas and hypotheses. Over time, changing technologies and expanding scientific understanding create new fields of interdisciplinary study and new ways of doing things.*



## 4th Grade

**OUTCOME:** Students can provide illustrative examples of science as an ongoing process that includes expanding, revising, and sometimes discarding theories based on new evidence, and that our understanding of a topic can change as more research is completed.

**EXAMPLE:** Students research the 2006 re-designation of Pluto from the status of planet to that of minor planet. Teams of students prepare arguments and create multimedia props recommending for or against the reclassification based on scientific reasoning and hold a classroom debate.

**OUTCOME:** Students can identify how improvements in scientific instruments can lead to new discoveries.

**EXAMPLE:** Students study the discovery of microscopic life forms as the source of infectious disease. Using inks that illuminate under ultraviolet light, students work in teams to determine the most effective hand-washing techniques and then create posters to teach their recommended protocol to fellow students.



## 8th Grade

**OUTCOME:** Students can identify the difference between scientific theories (which can be improved through new evidence and expanded through exceptions to observed patterns) and beliefs (which may or may not be based on evidence).

**EXAMPLE:** Students examine satellite images of the Earth and distinguish geologic structures from signs of plant and animal activity—including human-created patterns—then compare those patterns to images of other planets and their moons. This information is used as the basis for discussion on what evidence for life on other planets we might be able to detect.

**OUTCOME:** Students can provide examples that show how people often rely on scientific information to inform personal choices and societal practices, and that changes in scientific understanding can affect those choices.

**EXAMPLE:** Students research the historical development of a safety technology such as car seat belts or bike helmets, and examine product test data and actuarial data from online resources. Students present their findings, including multimedia charts and graphs, and discuss the implications of laws that require the use of these devices.



## 12th Grade

**OUTCOME:** Students are able to revise their own scientific ideas and hypotheses based on new evidence or information.

**EXAMPLE:** Students design their own means of observing and/or testing the Earth's direction of rotation that includes working remotely with students in other countries to investigate the commonly held idea that water goes down a drain in different directions in the northern and southern hemispheres.

**OUTCOME:** Students are able to successfully apply their scientific knowledge and scientific reasoning skills to a variety of situations and new areas of study.

**EXAMPLE:** Student teams choose a habit or practice in which they engage that carries risks about which they have concerns (sport injuries, flying in an airplane, eating fatty foods). They research the relative risks for those activities compared to other activities about which they don't generally worry. Students develop questions and data analysis measures for an online survey that they administer to their classmates. They analyze survey results to explore any discrepancies they discover in their research between perception and data.



# Initiative & Self-Direction

# SCIENCE



## 4th Grade

*As the nature of science is to raise questions, science cultivates initiative and self-direction, and encourages lifelong learning. Curiosity motivates scientific thinkers to make careful observations and try things out as a way to seek answers to questions and to develop solutions to identified problems.*

**OUTCOME:** Students are able to design an investigation based on a question they have generated from their own curiosity.

**EXAMPLE:** Students identify a favorite sport, hobby, or other area of personal interest and keep a question journal (paper or digital) about that interest, writing down a wide range of questions they may have about it. After a month, students examine their questions and categorize them by those that could be scientifically tested, researched, or observed versus those that would be answered by opinion. Finally, they share their questions with peers and through discussion, determine whether or not they are investigable questions.



## 8th Grade

**OUTCOME:** Students are aware of the broad range of careers and pastimes that involve scientific inquiry.

**EXAMPLE:** The school holds an event to showcase opportunities for students to be involved in amateur science interest groups and citizen science research projects. Representatives from local astronomy societies, rock and mineral clubs, birdwatching groups, science museum volunteer programs, university outreach, and other informal learning groups are invited to present. Students interview guests using classroom-developed questions that inquire about initiative, self-direction, and external influences that affected their career choices and scientific interests.



## 12th Grade

**OUTCOME:** Students have a variety of opportunities to read/view and interpret scientific information through both popular and professional media in areas that interest them, and are able to discuss their thoughts and questions on these topics informally with peers.

**EXAMPLE:** Students form discussion groups or join with existing groups, either face-to-face or through online social networking tools, to enable regular conversations around science-related topics (current events, books or articles, television programs, the accuracy of the science in Hollywood movies). They create shared web browser bookmarks to identify resources of interest for their peers.





# Social & Cross-Cultural Skills

# SCIENCE



## 4th Grade

*Social and cross-cultural skills are important to science because doing science involves many different kinds of work and engages men and women of all ages, backgrounds, and physical abilities. Science is advanced by synthesizing the different observations, perspectives, opinions, and interpretations of many individuals.*

**OUTCOME:** Students can describe ways that people from many cultures, backgrounds, and abilities participate in science.



**EXAMPLE:** Students interact via email or webconferencing with teams of international scientists, working together on a research initiative such as the International Space Station, the Intergovernmental Panel on Climate Change, or an Antarctic research station.



## 8th Grade

**OUTCOME:** Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives.

**EXAMPLE:** Students learn basic group facilitation techniques and decide as a class how to apply them to improve their own scientific processes and discussions. Students identify and rank higher-to-lower quality facilitation and discussion techniques and norms. Students videotape class labs and other science activities to critique their own application of equitable practices, using classroom-developed protocols.



## 12th Grade

**OUTCOME:** Students can explain how personal, societal, and cultural perspectives influence the scientific questions people pursue, and how people interpret scientific information.



**EXAMPLE:** After studying the background content of a current scientific or technology related issue, discovery, or event, student teams use online news sources and internet radio broadcasts from other countries to compare and contrast international coverage of the topic with that of U.S. media. Students identify different uses of wording, including persuasive, derogatory, etc. Students examine how the informational and editorial aspects of reporting on science might be different in other cultures and in diverse American sub-cultures, then use social networking tools or wikis to discuss these differences with students in other regions of the country or other countries.



# Productivity & Accountability

# SCIENCE



## 4th Grade

*The high ethical standards and collaborative nature of science promote expectations for accountability and productivity. Scientists use a variety of tools and instruments to enhance their ability to produce and replicate accurate data, and to meet expectations for sharing their findings with the scientific community and general public.*

**OUTCOME:** Students identify a variety of tools and techniques that scientists use to gather scientific information depending on what it is they want to know and the circumstances under which data will be collected.

**EXAMPLE:** Student teams use various methods to record weather data over a two-week period. One group tracks only what is reported in the news, one group writes down their observations, another makes photographic records of daily weather, another takes readings using probeware. Students discuss the different data collection techniques and their relative accuracy, their usefulness at different scales and for different purposes, and other pros and cons.



## 8th Grade

**OUTCOME:** Students can articulate the importance of accurate data collection and record keeping in science, and are able to demonstrate good practices for data collection, and identify common sources of error.

**EXAMPLE:** Student groups in a physical science class design experiments to examine how different sources of error can impact the results of a lab activity focused on the relationship between force, mass, and acceleration. Groups document both the experiment design and their results, then give their descriptions to another group to repeat the experiment based solely on their instructions. Groups compare methods and data for their different trials and discuss similarities and differences in their results.



## 12th Grade

**OUTCOME:** Students can describe and provide examples of how people may be impacted positively or negatively by the outcomes of scientific studies, technical developments, and scientific approaches applied to real world problems.

**EXAMPLE:** Students engage in a role-playing scenario based on real science and geography that models a city's decision to either rebuild or relocate homes that have been destroyed in a natural disaster. Student roles include scientists, civil engineers, government officials, relief workers, insurance industry representatives, news media, and homeowners. The class develops criteria for scientific use of data, analysis processes, and accountability of the impact for different roles on project outcomes.



# Leadership & Responsibility



## 4th Grade

*Science involves a code of conduct that is openly and frequently discussed, with high standards for ethical responsibility around referencing the work of others, drawing conclusions based on evidence, recognizing the potential for bias, avoiding political and financial influence, constructing and conducting safe investigations, and appropriately applying research results and other scientific knowledge.*

**OUTCOME:** Students can describe how doing science carries responsibilities for assuring the safety and rights of others and can provide examples of their own responsibilities while doing science activities at school.

**EXAMPLE:** Students visit a farm, zoo, or animal shelter to research the basic requirements and ethical issues of keeping live animals in captivity, including a focus on the safety of the animals, handlers, and visitors. They discuss what would be appropriate and inappropriate ways to keep animals in the classroom and use digital images (photos or video) and text to create a handbook for keeping live animals.



## 8th Grade

**OUTCOME:** Students understand the importance of proper citations and respect for intellectual property rights.

**EXAMPLE:** Students investigate ways that the works and ideas of others are referenced in different types of media including scientific papers, news magazines, television programs, and both professional and popular science websites. They gather and compare what they consider to be good and bad examples. Students discuss why citations are important and what the challenges are for proper referencing (e.g., tracking ownership of online materials), then use screen capture software to create a tutorial for their peers that explains guidelines and tools (including citation software and social bookmarking sites) that can help them adhere to proper intellectual property practices.



## 12th Grade

**OUTCOME:** Students recognize the role of science in society and can identify potential sources of bias and influence that can affect scientific research and the use and reporting of scientific information.

**EXAMPLE:** Students gather information about alternative energies such as biofuels, wind generators, or nuclear power plants from a variety of sources. They document the location and format of the information, what organizations or individuals published it, how it was funded, and the key arguments or statements made. They analyze and categorize the information to determine potential biases and to distinguish opinion and hearsay from claims based on evidence.





# Interdisciplinary Themes

# SCIENCE



## Global Awareness

Science is an international enterprise that benefits from cross-cultural perspectives and multi-national collaborations. Many pressing issues of scientific study can only be addressed on a global systems scale.

## Financial, Economic, Business and Entrepreneurial Literacy

Scientific information and the products of science and technology research are increasingly integral to the U.S. and global economies, including new business sectors that are rapidly arising from interdisciplinary research areas (e.g., biotechnology, nanotechnology, alternative energies). Funding basic scientific research and development is an essential precursor to sparking science and technology business innovations. Understanding basic science concepts behind commercial products and services can help inform consumer choices, and the scientific processes of data interpretation and modeling facilitate financial analysis and planning.



## Civic Literacy

Scientific literacy is important to making informed civic decisions, as communities increasingly must determine policies and regulations related to environmental health, natural resources management, civil engineering, and human wellness.

## Health Literacy

Health literacy is developed through understanding of human biology and the role of humans in global ecosystems, including concepts of basic biology, disease transmission, nutrition, biotechnology, and bioethics. It is important that scientific knowledge and peer-reviewed research inform how health science information is gathered, evaluated, and applied at scales from personal choices to healthcare delivery to federal policymaking.



# Supporting Structures

# SCIENCE

The National Science Education Standards (NSES) (National Research Council, 1996) recommend areas of “less” and “more” educational emphasis, many of which align with the 21st Century Skills supporting structure categories. 21st Century learning tools, examples of which are provided in the table below, can enrich and support the NSES recommendations. Some of the emphasis statements have been paraphrased or combined relative to how they appear in the NSES.

	Less Emphasis on...	More Emphasis on...	21st Century Tools
<b>21st Century Standards</b>	<ul style="list-style-type: none"> <li>Acquiring information and recitation of acquired knowledge</li> </ul>	<ul style="list-style-type: none"> <li>Understanding scientific concepts, developing abilities of inquiry, and learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science</li> </ul>	<ul style="list-style-type: none"> <li>Use of probeware, mobile media devices, GIS and various online tools for data collection, as well as online data sets</li> <li>Online collaboration, conferencing, and communication tools for authentic research with peers and scientists</li> <li>Social networking sites</li> <li>Digital libraries</li> </ul>
<b>Assessment of 21st Century Skills</b>	<ul style="list-style-type: none"> <li>Using summative tests of discrete, factual information that is easily measured</li> <li>Assessing to learn what students do not know, and assessing only achievement</li> </ul>	<ul style="list-style-type: none"> <li>Assessing rich, well-structured knowledge, as well as scientific understanding and reasoning</li> <li>Engaging students in ongoing assessment of their work and that of others</li> <li>Assessing to learn what students do understand, as well as achievement and opportunity to learn</li> </ul>	<ul style="list-style-type: none"> <li>Electronic portfolios</li> <li>Online collaboration, conferencing, communication tools</li> <li>Social networking sites</li> <li>Media creation tools including software for graphic design, digital photo and video editing, and presentations</li> </ul>
<b>21st Century Curriculum and Instruction</b>	<ul style="list-style-type: none"> <li>Rigidly following curriculum</li> <li>Presenting knowledge through lecture, text, and demonstration</li> <li>Asking for recitation of acquired knowledge</li> <li>Providing textbook and lecture-driven curriculum with broad coverage of unconnected factual information</li> </ul>	<ul style="list-style-type: none"> <li>Selecting and adapting curriculum</li> <li>Guiding students in active, extended scientific inquiry</li> <li>Providing opportunities for scientific discussion and debate among students</li> <li>Providing curriculum that supports the standards, includes a variety of components (e.g., laboratories, emphasizing inquiry and field trips), and includes natural phenomena and science-related social issues that students encounter in everyday life</li> </ul>	<ul style="list-style-type: none"> <li>Access to the Web and personal computing</li> <li>Brainstorming, concept mapping software</li> <li>Computer-aided design, modeling software, and simulation software</li> <li>Digital production tools (digital photography and video)</li> <li>GIS and GPS tools</li> <li>Graphics software (drawing, painting, image editing)</li> <li>Digital libraries</li> <li>Multimedia resources (images, video, audio, animations, simulations, and educational games)</li> <li>Online courses and self-paced learning modules</li> </ul>

# Supporting Structures (continued)

## 21st Century Professional Development

### Less Emphasis on...

- Seeing teachers as based in classrooms, learning alone
- Separating theory and practice
- Transmitting teaching and content knowledge through lectures and reading
- Seeing teachers as consumers of knowledge
- Providing one-shot sessions, courses and workshops to teachers as technicians

### More Emphasis on...

- Treating teachers as professionals and as members of collegial communities
- Integrating theory and practice in the school setting
- Encouraging teachers to learn about science and science teaching through inquiry and investigation
- Employing long-term coherent plans including a variety of activities for reflective practitioners
- Seeing teachers as producers of knowledge
- Providing opportunities both for continual learning and networking for school improvement

### 21st Century Tools

- Ongoing professional development to promote an inquiry approach in the context of laboratory and field, as well as through use of technology
- Collaboration, conferencing, communication tools (online)
- Social networking tools
- Online courses and self-paced learning modules

## 21st Century Learning Environment

- Treating students alike and responding to them as a whole
- Maintaining responsibility and authority by the teacher, and supporting competition rather than collaboration
- Learning opportunities that favor one group

- Responding to individual students' interests, strengths, experiences, and needs
- Supporting a classroom community with cooperation, shared responsibility, and respect
- Providing challenging opportunities for all students to learn science

- Brainstorming and concept mapping software
- Online authoring, brainstorming, graphics, spreadsheet and presentation software
- Online collaboration, conferencing, communication tools
- Resources in the local community including people, places, institutions, and information
- Digital libraries
- Social networking sites
- Media creation tools including software for graphic design, digital photo and video editing, and presentations
- Online courses and self-paced learning modules