

# 21<sup>st</sup> Century Marine Science



Brevard Public Schools

Dr. Brian Binggeli, Superintendent

Summer 2014

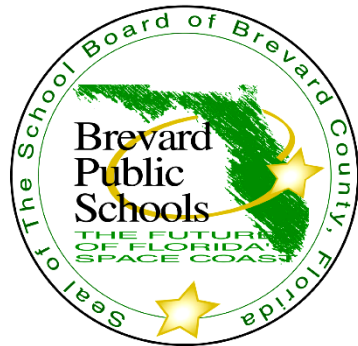
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2700 Judge Fran Jamieson Way  
Viera, Florida 32940-6601

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## **21<sup>st</sup> Century Science Curriculum Task Team Summer 2014**

Mary Anderson	West Shore Jr/Sr High School
Barbara Calhoun	Titusville High School
Colleen Graham	Astronaut High School
Jeff Higginbotham	Rockledge High School
Jacqueline Insalaco	Rockledge High School
John Latherow	Satellite High School
Nadia LeBohec	Bayside High School
Scott McCord	Cocoa Beach Jr/Sr High School
Raul Montes	Cocoa High School
Mary Ratliff	Palm Bay Magnet High School
Diane Wallschlag	Merritt Island High School
Sara Wyrick	Cocoa High School
Ginger Davis	Science Resource Teacher

### **Special thanks and acknowledgement to the following for their assistance in helping develop this curriculum guide**

Jean Almeida	Christina Sage
Andrea Crowley	Allan Sprayberry
Jennifer Heflick	Somer Sutton
Debbie Minor	Betty Walden
Maggie Molledo	Catherine Webb
Ellen Muse	Gary Wolfe
Laura Rouyeyrol	Elizabeth Youngs

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## How to Use this Document in PDF Form

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There are several other links to locations in this document or to outside resources. These links appear in [blue font](#) and are underlined. Clicking on the link will direct you to these resources. Searching within the document for a specific term or benchmark can be done by clicking “Edit” on the top menu bar of the PDF Page and selecting “Advanced Search” or “Search” or pressing shift, control, F simultaneously). Select “Search” in the current document and type in the term or benchmark desired in the “What word or phrase would you like to search for?” box and then click search. The first location the term or benchmark appears in the document will be displayed on the main document. Subsequent entries will appear in the search box to the left of the document. Click on the entries in the search box to move from one page to another where the term or benchmark is located.

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“Technology has come a long way, as have the teachers that use it and the students that learn from the use of it. We are living and teaching in another generation. A generation that sees more television, plays more computer games, and understands more about gadgets, devices, and web concepts than we would have ever expected in our lifetime. This is one of the key reasons that teaching with technology is such an important way to not only engage our students, but to relate to them as well.”

Emily Witt

# A Vision for Science Learning in the 21<sup>st</sup> Century

The bell rings! The students are in their seats. Waiting... The teacher slowly surveys the class with that “I’ve got a secret!” look. Apparently satisfied, the teacher fires off seven words in an almost inaudible mischievous tone: “Do you want to see something cool.?!?”

Young synapses surge with energy. Adrenaline flows. Enthusiastic hearts race. Eyes widen. And hands launch towards the sky. Silently, the teacher concludes: “They are ready.” In carefully measured movements, the teacher takes two arcane solutions and, with a hint of hesitation, slowly pours them into a tall glass cylinder. As the sound of liquid sloshing reaches the students’ ears, they hear a warning:

“Be on your guard students. No one knows what might happen.”

Young minds race...*engaged*.

The stage is set. The switch is thrown. The magnetic stirrer whirls. The solution begins to swirl and as the vortex swells in ever growing intensity, the mysterious concoction suddenly turns green.....then blue..... violet.....RED! And then, almost miraculously, the cycle repeats! Involuntary gasps escape from stimulated minds. The students don’t understand. They have never seen anything like this before. And they love it! The teacher knows that timing is everything and so, at just the right moment, the question is presented: “How does this work?” After a few seconds of silence, a follow-up question asks “would you like to *explore*?”

**“YES!”**

Soon, the classroom transforms into a beehive of purposeful creative activities: reflecting... planning... designing. Students-no-young scientists, scramble for materials in a lab brimming with an assortment of lab equipment, glassware, microscopes, computers, and technology. One group of students is using computers and probeware to check out a prediction. Another group is racing through the indexes of several books. Yet another group is searching the Internet. Questions from all directions assail the teacher. Debates spontaneously explode amongst the researchers. Predicting! Observing! Re-designing! Experimenting! Seeking! Analyzing!

The teacher can barely handle the tempo! And then.....

Suddenly, a student shrieks out involuntarily:

**“Eureka!”**

Another skeptical student challenges: “How do *you* know?” “Explain it to me!”

The class listens intently as the knowing student fires off a dynamic solution to the mystery of the phenomenon. Like a restless volcano, the class erupts again in new debates over alternative solutions, clarifications, and new questions: “If that’s true, then why...?” “Show me!” “What about this...?” “How do you know that it isn’t because of...?” “That doesn’t make sense to me!” “My data shows the same thing!”

The teacher thinks, “Mission accomplished!”

A stimulating and challenging science classroom encourages high level learning, skilled methodology, creative thinking, and focused problem solving. The integration of science concepts provides a solid foundation for understanding the world in which we live. Society is dependent upon how wisely we use science, as today and the future are being shaped by science and

technology. Science by its very nature encourages students to be active learners. Classroom experiences should include discussions, oral presentations, projects, and laboratory experiences. These can be best accomplished by collecting, manipulating, analyzing, and interpreting data. The high school science classroom provides a positive learning environment of meaningful teacher instruction as well as assessment and a wide variety of current resources and instructional methods. Since science relates to our daily lives, we must ensure that the Next Generation of students is scientifically literate. Accomplishing such a goal will empower our students to become productive, critical thinking citizens in the global community of the 21st century.

## Best Practices in Science

Throughout history, people have developed ideas about the world around them. These ideas in the physical, biological, social, and psychological realms have enabled successive generations to achieve increased understanding of our species and environment. These ideas were developed using particular ways of observing, thinking, experimenting, and validating. Such methods represent the nature of science and reveal science as a unique way of learning and knowing.

Science tends to reflect the following beliefs and attitudes:

- The universe is understandable.
- Scientific knowledge is durable
- Scientific ideas are subject to change.
- Science demands evidence.
- Science explains and predicts.
- Scientists identify and avoid bias.
- Science blends logic and imagination.
- Scientists follow ethical procedures.

## Quality Science Education and 21<sup>st</sup> Century Skills

Technological advancement, scientific innovation, increased globalization, shifting workforce demands, and pressures of economic competitiveness are but a few of the challenges that are rapidly changing our world. These changes are redefining the skill sets that students need to be adequately prepared to participate in and contribute to today's society (Levy and Murnane 2005; Stewart 2010; Wilmarth 2010).

Defining and identifying 21<sup>st</sup> century skills is now a big role for commercial and educational organizations. Core subject knowledge, learning and innovation skills, information, media, and technology skills, life and career skills, adaptability, complex communication/social skills, problem solving, self-management/self-development, and systems thinking are but a few of the skills that need to be mastered. Online resources are available at:

Partnership for 21<sup>st</sup> Century  
skills

<http://p21.org/>

**21<sup>st</sup> Century Science**



Project Based Learning for the 21<sup>st</sup> Century Skill Frameworks

[http://www.bie.org/research/21st\\_century\\_skills](http://www.bie.org/research/21st_century_skills)



Science education should foster deep content knowledge through active intellectual engagement emulating disciplinary practices and thinking; 21st-century skills focus on developing broadly applicable capacities, habits of mind, and preparing knowledge workers for a new economy (Windschitl 2009).

“Exemplary science education can offer a rich context for developing many 21st-century skills, such as critical thinking, problem solving, and information literacy especially when instruction addresses the nature of science and promotes use of science practices. These skills not only contribute to the development of a well-prepared workforce of the future but also give individuals life skills that help them succeed. Through quality science education, we can support and advance relevant 21<sup>st</sup> -century skills, while enhancing science practice through infusion of these skills.” (NSTA Position Statement on 21<sup>st</sup> Century Skills)

## **NGSS, NGSSS, Bodies of Knowledge and Florida Standards**

Science, engineering, and technology play an important role in modern life, and they also hold the key to meeting many of humanity’s most pressing current and future challenges. Yet too few U.S. workers have strong backgrounds in these fields, and many people lack even fundamental knowledge of them. This trend has created a widespread call for a new approach to K-12 science education in the United States. (*A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, 2012)

The Committee on a Conceptual Framework for New K-12 Science Education Standards has developed a framework that articulates expectations for students in science. The committee recommends that science education in grades K-12 be built around three major areas:

- Scientific and engineering practices
- Crosscutting concepts that unify the study of science and engineering through their common application across fields
- Core ideas in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science (*A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, 2012)

Next Generation Science Standards (NGSS) have been developed through a collaborative, state-led process. These standards are rich in content and practice, arranged in a coherent manner to provide students a well benchmarked science education. The NGSS are based on the *Framework for K-12 Science Education* developed by the National Research Council.

Florida Science courses were developed from the Next Generation Sunshine State Standards (NGSSS) and Florida Standards (FS). The Bodies of Knowledge (BOK) do not represent courses. Individual courses may have standards from more than one BOK and Florida Standards are repeated from one course to another. Benchmarks are considered appropriate for statewide assessment or end of course exams. Some Florida science courses have standards defined by other organizations such as College Board for Advanced Placement, AICE, or International Baccalaureate science courses). In addition, Florida Standards benchmarks in the areas of reading, writing, listening and mathematics have been added to Florida Science Course Descriptions.



**NGSSS Benchmark Coding Scheme, Science Content (SC)**

SC, Grade Level, Body of Knowledge, Standard, Benchmark

Example: SC.912.N.1.1

Body of Knowledge Key:

- N-Nature of Science
- E-Earth and Space Science
- P-Physical Science
- L-Life Science

**Florida Standards Coding Scheme, Language Arts Standards (LA)**

LAFS, Grade Level, Strand, Standard, Benchmark

Example: LAFS.1112.WHST.3.8

Reading Standards (R)

Literacy in Science &amp; Technical Subjects RST

Writing Standards (W)

Writing Standards for Literacy in History/Social Studies,  
Science & Technical Subjects WHST

Speaking &amp; Listening Standards

SL

**Florida Standards Coding Scheme, Mathematics Standards (MA)**

MAFS, Grade Level, Strand, Standard, Benchmark

Example: MAFS.912.F-IF.3.7

Number and Quantity (N)

Real Number System N-RN

Quantities N-Q

Complex Number Systems N-CN

Vector and Matrix Quantities N-VM

Algebra (A)

Seeing Structure in Expressions A-SSE

Arithmetic with Polynomials and Rational Expression A-APR

Creating Equations A-CED

Reasoning with Equations and Inequalities A-REI

Functions (F)

Interpreting Functions F-IF

Building Functions F-BF

Linear, Quadratic, and Exponential Models F-LE

Trigonometric Functions F-TF

Modeling (M)

Geometry (G)

Congruence G-CO

Similarity, Right Triangles, and Trigonometry G-SRT

Circles G-C

Expressing Geometric Properties with Equations G-GPE

Geometric Measurements and Dimensions G-GMD

Modeling with Geometry G-MG

Statistics and Probability (SP)

Interpreting Categorical and Quantitative Data S-ID

Making Inferences and Justifying Conclusions S-IC

Conditional Probability and the Rules of Probability S-CP

Using Probability to Make Decisions S-MD

## NGSSS Bodies of Knowledge Grades 9-12 Standards

### **Body of Knowledge: NATURE OF SCIENCE**

#### **Standard 1: The Practice of Science**

- A. Scientific inquiry is a multifaceted activity; the processes of science include the formulation of scientifically investigable questions, construction of investigations into those questions, the collection of appropriate data, the evaluation of the meaning of those data, and the communication of this evaluation.
- B. The processes of science frequently do not correspond to the traditional portrayal of "the scientific method."
- C. Scientific argumentation is a necessary part of scientific inquiry and plays an important role in the generation and validation of scientific knowledge.
- D. Scientific knowledge is based on observation and inference; it is important to recognize that these are very different things. Not only does science require creativity in its methods and processes, but also in its questions and explanations.

#### **Standard 2: The Characteristics of Scientific Knowledge**

- A. Scientific knowledge is based on empirical evidence, and is appropriate for understanding the natural world, but it provides only a limited understanding of the supernatural, aesthetic, or other ways of knowing, such as art, philosophy, or religion.
- B. Scientific knowledge is durable and robust, but open to change.
- C. Because science is based on empirical evidence it strives for objectivity, but as it is a human endeavor the processes, methods, and knowledge of science include subjectivity, as well as creativity and discovery.

#### **Standard 3: The Role of Theories, Laws, Hypotheses, and Models**

The terms that describe examples of scientific knowledge, for example: "theory," "law," "hypothesis" and "model" have very specific meanings and functions within science.

#### **Standard 4: Science and Society**

As tomorrow's citizens, students should be able to identify issues about which society could provide input, formulate scientifically investigable questions about those issues, construct investigations of their questions, collect and evaluate data from their investigations, and develop scientific recommendations based upon their findings.

### **Body of Knowledge: EARTH AND SPACE SCIENCE**

#### **Standard 5: Earth in Space and Time**

The origin and eventual fate of the Universe still remains one of the greatest questions in science. Gravity and energy influence the development and life cycles of galaxies, including our own Milky Way Galaxy, stars, the planetary systems, Earth, and residual material left from the formation of the Solar System. Humankind's need to explore continues to lead to the development of knowledge and understanding of the nature of the Universe.

#### **Standard 6: Earth Structures**

The scientific theory of plate tectonics provides the framework for much of modern geology. Over geologic time, internal and external sources of energy have continuously altered the features of Earth by means of both constructive and destructive forces. All life, including human civilization, is dependent on Earth's internal and external energy and material resources.

#### **Standard 7: Earth Systems and Patterns**

The scientific theory of the evolution of Earth states that changes in our planet are driven by the flow of energy and the cycling of matter through dynamic interactions among the atmosphere, hydrosphere, cryosphere, geosphere, and biosphere, and the resources used to sustain human civilization on Earth.

## Body of Knowledge: PHYSICAL SCIENCE

### Standard 8: Matter

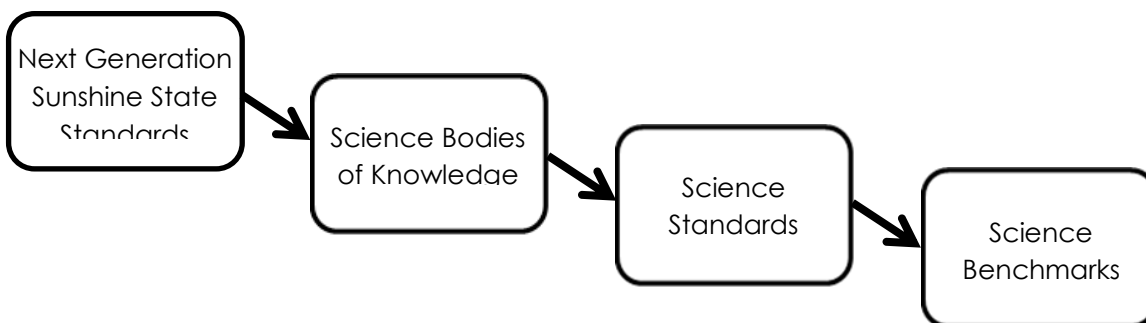
- A. A working definition of matter is that it takes up space, has mass, and has measurable properties. Matter is comprised of atomic, subatomic, and elementary particles.
- B. Electrons are key to defining chemical and some physical properties, reactivity, and molecular structures. Repeating periodic) patterns of physical and chemical properties occur among elements that define groups of elements with similar properties. The periodic table displays the repeating patterns, which are related to the atom's outermost electrons. Atoms bond with each other to form compounds.
- C. In a chemical reaction, one or more reactants are transformed into one or more new products. Many factors shape the nature of products and the rates of reaction.
- D. Carbon-based compounds are building-blocks of known life forms on earth and numerous useful natural and synthetic products.

### Standard 10: Energy

- A. Energy is involved in all physical and chemical processes. It is conserved, and can be transformed from one form to another and into work. At the atomic and nuclear levels energy is not continuous but exists in discrete amounts. Energy and mass are related through Einstein's equation  $E=mc^2$ .
- B. The properties of atomic nuclei are responsible for energy-related phenomena such as radioactivity, fission and fusion.
- C. Changes in entropy and energy that accompany chemical reactions influence reaction paths. Chemical reactions result in the release or absorption of energy.
- D. The theory of electromagnetism explains that electricity and magnetism are closely related. Electric charges are the source of electric fields. Moving charges generate magnetic fields.
- E. Waves are the propagation of a disturbance. They transport energy and momentum but do not transport matter.

### Standard 12: Motion

- A. Motion can be measured and described qualitatively and quantitatively. Net forces create a change in motion. When objects travel at speeds comparable to the speed of light, Einstein's special theory of relativity applies.
- B. Momentum is conserved under well-defined conditions. A change in momentum occurs when a net force is applied to an object over a time interval.
- C. The Law of Universal Gravitation states that gravitational forces act on all objects irrespective of their size and position.
- D. Gases consist of great numbers of molecules moving in all directions. The behavior of gases can be modeled by the kinetic molecular theory.
- E. Chemical reaction rates change with conditions under which they occur. Chemical equilibrium is a dynamic state in which forward and reverse processes occur at the same rates.



**Body of Knowledge: LIFE SCIENCE**

**Standard 14: Organization and Development of Living Organisms**

- A. Cells have characteristic structures and functions that make them distinctive.
- B. Processes in a cell can be classified broadly as growth, maintenance, reproduction, and homeostasis.
- C. Life can be organized in a functional and structural hierarchy ranging from cells to the biosphere.
- D. Most multicellular organisms are composed of organ systems whose structures reflect their particular function.

**Standard 15: Diversity and Evolution of Living Organisms**

- A. The scientific theory of evolution is the fundamental concept underlying all of biology.
- B. The scientific theory of evolution is supported by multiple forms of scientific evidence.
- C. Organisms are classified based on their evolutionary history.
- D. Natural selection is a primary mechanism leading to evolutionary change.

**Standard 16: Heredity and Reproduction**

- A. DNA stores and transmits genetic information. Genes are sets of instructions encoded in the structure of DNA.
- B. Genetic information is passed from generation to generation by DNA in all organisms and accounts for similarities in related individuals.
- C. Manipulation of DNA in organisms has led to commercial production of biological molecules on a large scale and genetically modified organisms.
- D. Reproduction is characteristic of living things and is essential for the survival of species.

**Standard 17: Interdependence**

- A. The distribution and abundance of organisms is determined by the interactions between organisms, and between organisms and the non-living environment.
- B. Energy and nutrients move within and between biotic and abiotic components of ecosystems via physical, chemical and biological processes.
- C. Human activities and natural events can have profound effects on populations, biodiversity and ecosystem processes.

**Standard 18: Matter and Energy Transformations**

- A. All living things are composed of four basic categories of macromolecules and share the same basic needs for life.
- B. Living organisms acquire the energy they need for life processes through various metabolic pathways primarily photosynthesis and cellular respiration).
- C. Chemical reactions in living things follow basic rules of chemistry and are usually regulated by enzymes.
- D. The unique chemical properties of carbon and water make life on Earth possible.



NGSSS Standards and Course Descriptions can be found on CPALMS, a resource repository for Florida Educators.

Standards:

<http://www.cpalms.org/Standards/FLStandardSearch.aspx>

Course Descriptions:

<http://www.cpalms.org/Courses/CourseDescriptionSearch.aspx>

## Florida Standards Language Arts (LA) Reading Standards Science and Technical Subjects

### Key Ideas and Details

#### Grades 9-10

1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
2. Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

#### Grades 11-12

1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

### Craft and Structure

#### Grades 9-10

4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.
5. Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

#### Grades 11-12

4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.
5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

*All men by nature desire knowledge.*

*Aristotle*

## **Integration of Knowledge and Ideas**

### **Grades 9-10**

7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
8. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

### **Grades 11-12**

7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

## **Range of Reading and Level of Text Complexity**

### **Grades 9-10**

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently.

### **Grades 11-12**

10. By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.



**FLORIDA STANDARDS**  
flstandards.org

## Florida Standards Language Arts (LA) Writing Standards History, Science and Technical Subjects

### Text Types and Purposes

#### Grades 9-10

1. Write arguments focused on *discipline-specific content*.
  - a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
  - b. Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
  - c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
  - d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
  - e. Provide a concluding statement or section that follows from or supports the argument presented.
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
  - a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
  - b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
  - c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.
  - d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
  - e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
  - f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).

#### Grades 11-12

1. Write arguments focused on *discipline-specific content*.
  - a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
  - b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.
  - c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
  - d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.
  - e. Provide a concluding statement or section that follows from or supports the argument presented.
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
  - a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
  - b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
  - c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.
  - d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.
  - e. Provide a concluding statement or section that follows from and supports the information or explanation provided.



### **Text Types and Purposes (continued)**

#### **Grades 9-10**

3. Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In history/social studies, students must be able to incorporate narrative accounts into their analyses of individuals or events of historical import. In science and technical subjects, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations or technical work that others can replicate them and (possibly) reach the same results.

#### **Grades 11-12**

3. Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In history/social studies, students must be able to incorporate narrative accounts into their analyses of individuals or events of historical import. In science and technical subjects, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations or technical work that others can replicate them and (possibly) reach the same results.

### **Production and Distribution of Writing**

#### **Grades 9-10**

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

#### **Grades 11-12**

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

*Words - so innocent and powerless as they are, as standing in a dictionary, how potent for good and evil they become in the hands of one who knows how to combine them.*

Nathaniel Hawthorne

**Research to Build and Present Knowledge  
Grade 9-10**

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
9. Draw evidence from informational texts to support analysis, reflection, and research.

**Grades 11-12**

7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
9. Draw evidence from informational texts to support analysis, reflection, and research. (day or two) for a range of discipline-specific tasks, purposes, and audiences.

**Range of Writing  
Grades 9-10**

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a

**Grades 11-12**

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.



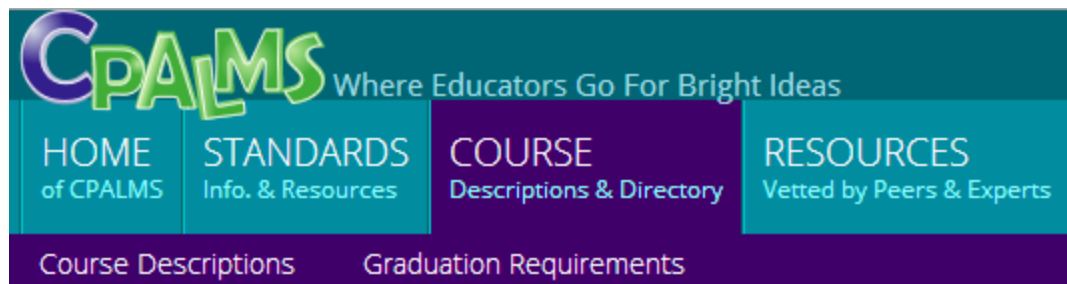
## Florida Standards Language Arts (LA) Speaking & Listening Standards

### Comprehension and Collaboration

- Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
- Come to discussions prepared having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
- Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed.
- Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.
- Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.
- Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
- Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

### Presentation of Knowledge and Ideas

- Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.
- Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.



## Florida Standards Mathematics (MA) Standards

### Mathematical Practices Grades 9-12

Standards for Mathematical Practice describe varieties of expertise that educators at all levels should seek to develop in their students. These practices rest on important “processes and proficiencies” with longstanding importance in education.

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- Model with mathematics. (application of scientific relationships)
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

### Number and Quantity Overview Grades 9-12

#### The Real Number System

- Extend the properties of exponents to rational exponents
- Use properties of rational and irrational numbers

#### Quantities

- Reason quantitatively and use units to solve problems

#### The Complex Number System

- Perform arithmetic operations with complex numbers
- Represent complex numbers and their operations on the complex plane
- Use complex numbers in polynomial identities and equations

#### Vector and Matrix Quantities

- Represent and model with vector quantities
- Perform operations on vectors
- Perform operations on matrices and use matrices in applications

### Algebra Overview Grades 9-12

#### Seeing Structure in Expressions

- Interpret the structure of expressions
- Write expressions in equivalent forms to solve problems

#### Arithmetic with Polynomials and Rational Functions

- Perform arithmetic operations on polynomials
- Understand the relationship between zeros and factors of polynomials
- Use polynomial identities to solve problems
- Rewrite rational functions

#### Creating Equations

- Create equations that describe numbers or relationships

#### Reasoning with Equations and Inequalities

- Understand solving equations as a process of reasoning and explain the reasoning
- Solve equations and inequalities in one variable
- Solve systems of equations
- Represent and solve equations and inequalities graphically

## **Functions Overview Grades 9-12**

### **Interpreting Functions**

- Understand the concept of a function and use function notation
- Interpret functions that arise in applications in terms of the context
- Analyze functions using different representations

### **Building Functions**

- Build a function that models a relationship between two quantities
- Build new functions from existing functions

### **Linear, Quadratic, and Exponential Models**

- Construct and compare linear and exponential models and solve problems
- Interpret expressions for functions in terms of the situation they model

### **Trigonometric Functions**

- Extend the domain of trigonometric functions using the unit circle
- Model periodic phenomena with trigonometric functions
- Prove and apply trigonometric identities

## **Modeling Overview Grades 9-12**

- Modeling links classroom mathematics and statistics to everyday life, work, and decision-making. Modeling is the process of choosing and using appropriate mathematics and statistics to analyze empirical situations, to understand them better, and to improve decisions. Quantities and their relationships in physical, economic, public policy, social, and everyday situations can be modeled using mathematical and statistical methods. When making mathematical models, technology is valuable for varying assumptions, exploring consequences, and comparing predictions with data.

## **Geometry Overview Grades 9-12**

### **Congruence**

- Experiment with transformations in the plane
- Understand congruence in terms of rigid motions
- Prove geometric theorems
- Make geometric constructions

### **Similarity, Right Triangles, and Trigonometry**

- Understand similarity in terms of similarity transformations
- Prove theorems involving similarity
- Define trigonometric ratios and solve problems involving right triangles
- Apply trigonometry to general triangles

### **Circles**

- Understand and apply theorems about circles
- Find arc lengths and areas of sectors of circles

### **Expressing Geometric Properties with Equations**

- Translate between the geometric description and the equation for a conic section
- Use coordinates to prove simple geometric theorems algebraically

### **Geometric Measurement and Dimension**

- Explain volume formulas and use them to solve problems
- Visualize relationships between two-dimensional and three-dimensional objects

### **Modeling with Geometry**

- Apply geometric concepts in modeling situations

## Statistics and Probability Overview 9-12

### Interpreting Categorical and Quantitative Data

- Summarize, represent, and interpret data on a single count or measurement variable
- Summarize, represent, and interpret data on two categorical and quantitative variables
- Interpret linear models

### Making Inferences and Justifying Conclusions

- Understand and evaluate random processes underlying statistical experiments
- Make inferences and justify conclusions from sample surveys, experiments and observational studies

### Conditional Probability and the Rules of Probability

- Understand independence and conditional probability and use them to interpret data
- Use the rules of probability to compute probabilities of compound events in a uniform probability model

### Using Probability to Make Decisions

- Calculate expected values and use them to solve problems
- Use probability to evaluate outcomes of decisions



*Science is simply common sense at its best, that is, rigidly accurate in observation, and merciless to fallacy in logic.*

Thomas Henry Huxley

## What Does Research Say about the Brain and Learning?

Learning is the process of discovering and constructing meaning from information and experience, filtered through our own unique perceptions, thoughts, feelings, and beliefs.

Advances in understanding how the brain learns can help teachers structure more meaningful lessons. The brain learns by connecting new information to concepts and ideas that it already understands (*Resnick 1998; Willis 2008, Braasch 2013*).

Learning environments must feel emotionally safe for learning to take place. For example, students should not be afraid of offering opinions or hypotheses about the content they are studying (*Howard 1994; Jensen 1998; McGaugh et al., 1993; Hinton, Miyamoto and Chiesa 2008, Baroncelli 2010*).

Each brain needs to make its own meaning of ideas and skills. Students need to be able to relate the learning to personal experiences provided for them. To learn, students must experience appropriate levels of challenge without being frustrated.

The brain learns best when it “does” rather than when it “absorbs” (*Pally 1997*). For example, students could be presented with a problem and asked to design and carry out a project to solve it (*Shultz, Dayan & Montague, 1997; Fedlstein and Benner 2004, Carbonneau 2012*).

### Online Resources on Brain Research and Learning

Brainfacts.org

<http://www.brainfacts.org/>

Twelve brain/mind learning principles:

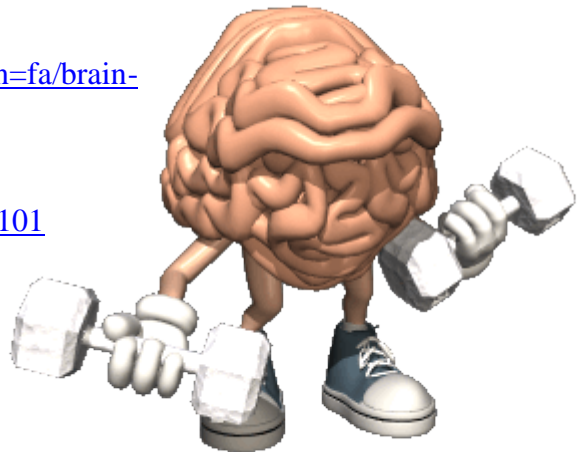
<http://brainconnection.positscience.com/topics/?main=fa/brain-based2>

Understanding How the Brain Learns

<http://nichcy.org/schoolage/effective-practices/brain101>

BRAINPOWER: From Neurons to Networks  
(YouTube video)

<http://www.youtube.com/watch?v=zLp-edwiGUU&list=PLrS5ViQHBtVONTnQdHuabC-IMCE7IOZuo>



*The brain is like a muscle. When it is in use we feel very good. Understanding is joyous.*

Carl Sagan

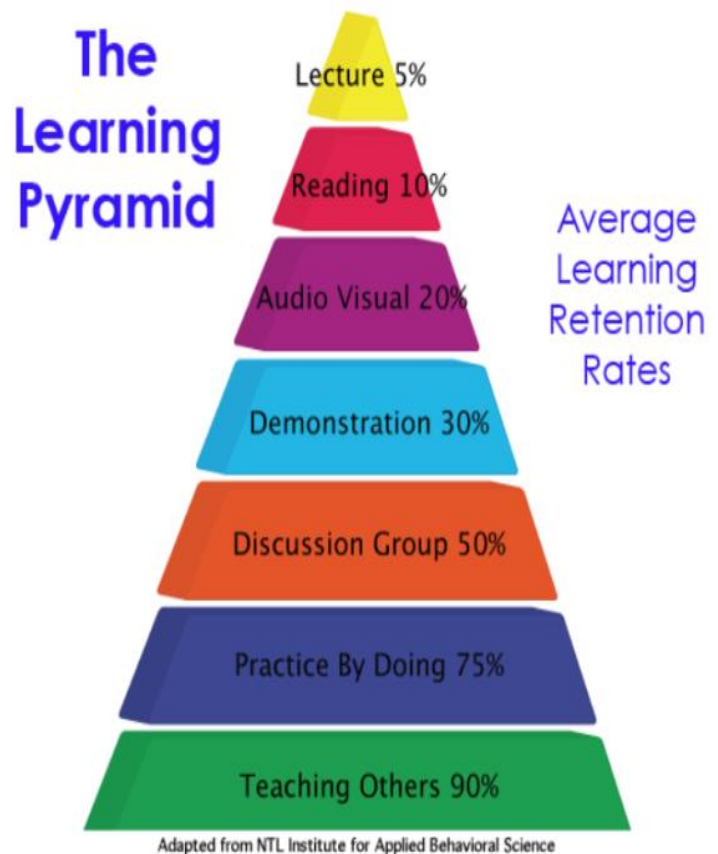
# Strategies to Incorporate into Science Lessons

As science teachers, we understand that learning is a process. This process works best when new knowledge is connected to prior knowledge by the teaching of meaningful lessons. Lessons related to personal experiences and taught in an emotionally safe environment allow for greater retention.

**40% of science instruction time should be devoted to activities involving the manipulation, collecting and analyzing of data. By using these strategies, students will have positive experiences and become actively engaged in inquiry, scientific processes, and problem solving.**

The teacher should.....

- Relate what students already know to the new concept.
- Build on prior understanding, identify and resolve existing misconceptions.
- Use a variety of science resources, use books, periodicals, multimedia technology, and up to date information.
- Emphasize the real life relevance of science.
- Relate science to daily life and encourage students to apply their own experiences to science.
- Ask probing questions to encourage student discussion and develop understanding.
- Involve students in sustained, in-depth projects rather than just "covering the textbook".
- Engage students in unifying topics which can be fully explored.
- Integrate subject matter to exemplify how the disciplines co-exist in actual practice. Science and other subject areas should be integrated to unify concepts and disciplines.
- Promote collaboration among students.
- Engage students in cooperative learning and small group projects to build understanding.
- Actively engage students in scientific processes and inquiry by having students actively engage in the manipulation, collecting and analysis of data.
- Encourage students to communicate.
- Allow students to make oral presentations, class discussions, complete interactive notebooks, and use data logs.
- Use meaningful and varied assessments.
- Focus on student understanding rather than on memorized definitions.





## Brevard Effective Strategies for Teachers (B.E.S.T.) and the 5E Model

B.E.S.T is an instructional model that creates a common language of effective instruction for Brevard’s teachers and administrators. B.E.S.T. incorporates research-based practices and knowledge of how the learner learns to provide an integrated model that teachers can use as a benchmark for analysis, reflection, and planning; and that administrators and instructional coaches can use to guide continuous improvement of instruction. B.E.S.T. also supports and reinforces the 5E model of instruction.

The 5E model of instruction includes 5 phases: engage, explore, explain, elaborate, and evaluate. Roger Bybee, in his book, *Achieving Scientific Literacy*, states: “Using this approach, students redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment. Learners interpret objects and phenomena and internalize those interpretations in terms of their current conceptual understanding.”

- **Engage** students so that they feel a personal connection with the topic.
- Provide students an opportunity to **explore** the topic through their own activities and investigations.
- Help students **explain** their findings once they have constructed meaning from their own experiences.
- Allow students to **elaborate** by constructing convincing lines of evidence to support their suppositions.
- Work with students to **evaluate** their understanding of science concepts, problem solving abilities, and inquiry skills.

Today’s innovative science classrooms require that educators provide the most useful and engaging educational experiences possible. This section provides examples of many helpful strategies. They may be adapted and refined to best fit the needs of students and/or instructional plans.



**Online Resources on the 5E Model and B.E.S.T.**

Order Matters: Using the 5E Model to Align Teaching with How People Learn  
<http://www.lifescied.org/cgi/content/full/9/3/159>

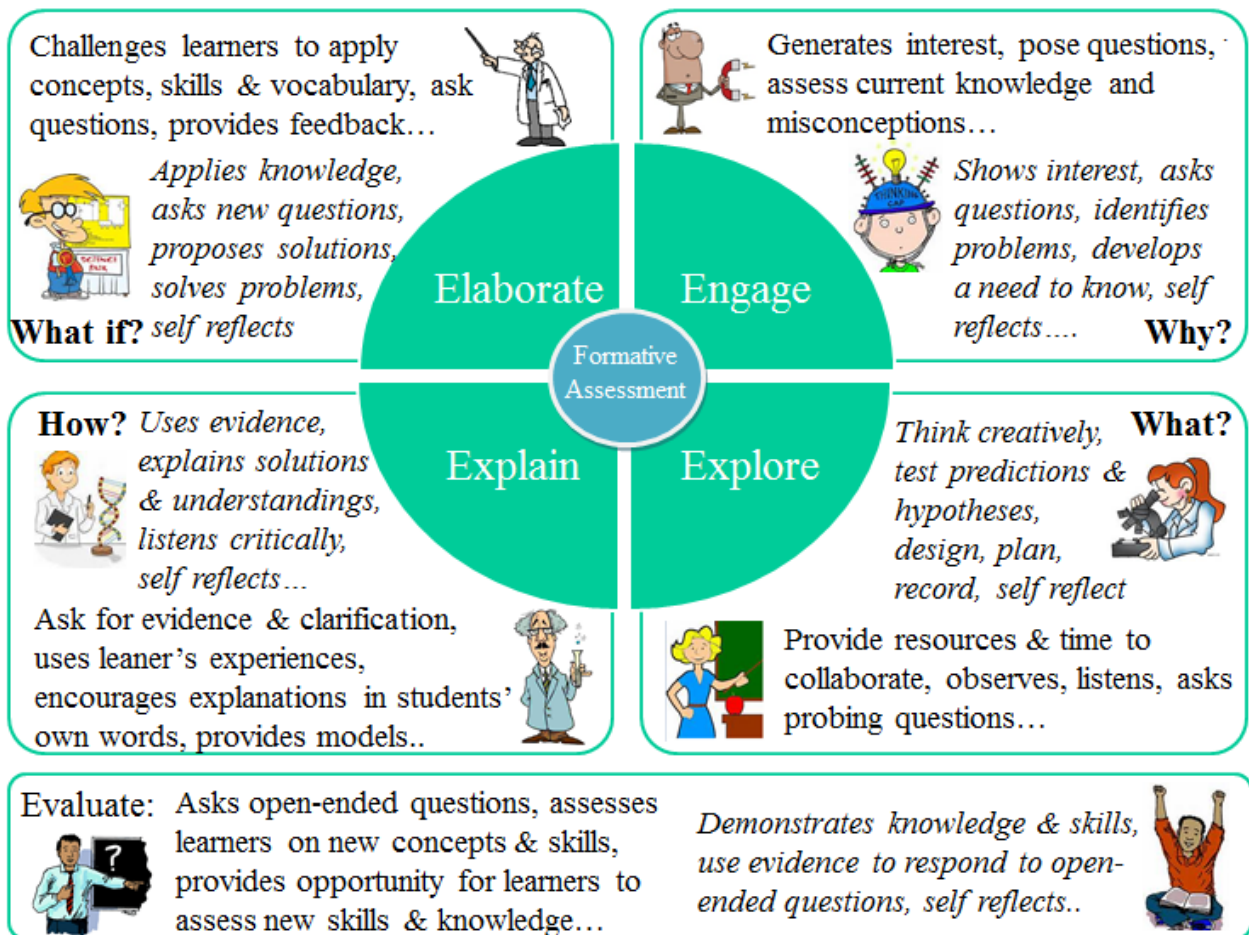
What the teacher and student should do in the 5E Model  
<http://science.education.nih.gov/supplements/nih6/inquiry/guide/implementing.htm>

Florida DOE 5E White Sheet CCLA Standards Support Science  
<http://goo.gl/Ri40Y>

Additional information on B.E.S.T. can be found at the BPS website....  
<http://best.brevardschools.org/best/default.aspx> (Intranet accessible only)

**5E Model and the B.E.S.T. Learning Cycle**

- What the teacher should do?
- What the student should do?



## Laboratory Investigations

Experimental investigations are central to teaching science. Investigations are the guiding force for science in the real world and must be integrated into the science curriculum.

Florida Standards construct a strong foundation for experiencing the process of scientific inquiry, which includes research, communication, written analysis and formal presentation of results and conclusion.

Teachers should not look for a way to fit investigations; rather, investigations should be a tool for introducing, reinforcing, and assessing student understanding of science and Florida Standards benchmarks. Great effort should be made to ensure that students are not simply going through the motions but instead are actively engaged in the design and implementation of investigations.

Many successful science programs emphasize the use of an interactive notebook. This notebook is a record of the author's thinking process as well as a log of the events that took place during the investigation. (Information on interactive notebooks can be found on page 31 of this document.)

Documentation and reflection are important life-long skills that are essential to scientists, but are also important in other activities and professions. A well developed and planned experimental investigation provides a better understanding of a science concept through actively engaging students in the process of science.

### How Do You Use It?

- Students develop a hypothesis and conduct investigations
- Students evaluate and verify data
- Students analyze the data collected and draw conclusions from the results
- Students report the results orally, in writing, or with a picture,
- Students evaluate a speaker's reasoning and use of evidence

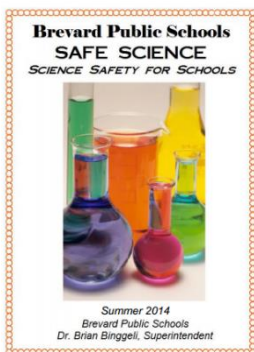
### What Are the Benefits?

- Students visualize science concepts and participate in science processes
- Students can experience the way some scientists work
- Students can learn there may not be an answer to a question or there may be many answers
- Students develops process skills

**Lab Report:** The lab report should clearly summarize the investigation, key items might include:

- Develop and write scientific hypothesis, procedures, data collecting organizers, and concluding explanations
- Choose a level of accuracy when reporting quantities
- Represent data
  - compare different data sets
  - interpret data sets and identify outliers
  - recognize associations and trends in data
  - interpret relationships in graphs and tables
  - show key features of a graph
- Evaluate and verify data
- Use and interpret units consistently
- Choose the appropriate scale in graphs and data displays, provide analysis and interpretation
- Present information and findings
  - participate in collaborative discussions
  - evaluate and note discrepancies among data

## Science Safety



Safety should always be a primary concern for the teacher in the science classroom and laboratory. Science teachers are responsible for safety equipment in the classroom, student safety in the classroom and laboratory, and safe student performance in a lab or class activity. It is the teacher's responsibility to review the Safety Guide,

*Brevard Public Schools  
Safe Science – Science Safety for Schools, 2014*

[http://www.edline.net/pages/Brevard\\_County\\_Schools/Departments/Departments\\_A-J/Curriculum\\_and\\_Instruction/Groups/High\\_School\\_Science](http://www.edline.net/pages/Brevard_County_Schools/Departments/Departments_A-J/Curriculum_and_Instruction/Groups/High_School_Science)

## Essential Questions

Essential questions establish a framework and context for learning. They provide purpose and relevance, and define the essence of the course, unit or lesson.

A question is essential when it:

- causes genuine and relevant inquiry into the big ideas and core content;
- provokes deep thought, lively discussion, sustained inquiry, and new understanding as well as more questions;
- requires students to consider alternatives, weigh evidence, support their ideas, and justify their answers;
- stimulates vital, on-going rethinking of big ideas, assumptions, and prior lessons;
- sparks meaningful connections with prior learning and personal experiences;
- naturally recurs, creating opportunities for transfer to other situations and subjects.

### Online Resources on Essential Questions

Technology Connection-Essential Questions

<http://daretodifferentiate.wikispaces.com/file/view/essential.pdf>

Understanding by Design: Essential Questions

<http://www.huffenglish.com/?p=363>

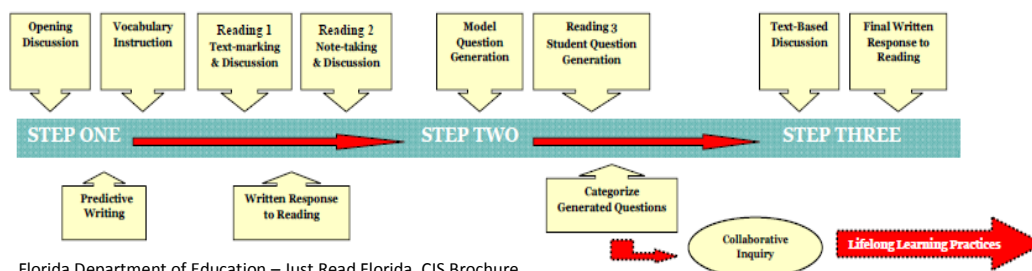
Scholastic Teachers: Essential Questions

<http://www.scholastic.com/teachers/article/essential-questions>

## Comprehension Instructional Sequence (CIS)

Students need supportive challenges in interacting with complex content-area information in order to be college and career-ready for lifelong learning. CIS is a complex form of multiple-strategy instruction that promotes student development in reading comprehension, vocabulary, content-area knowledge, and critical thinking about complex texts. A CIS lesson is delivered in three steps with integrated and sustained text-based discussions and writing used throughout. Multiple readings of the same text facilitate deeper thinking.

- Lessons contain explicit instruction in vocabulary and close reading through text-marking and directed note-taking.
- Students generate questions that launch them into collaborative inquiry, supporting the practice of lifelong learning.
- Lessons challenge students to use text evidence to validate positions they have formed over the course of the lesson.



### Online Resources on CIS Model

Comprehension Instructional Sequence Flowchart.pdf

<http://goo.gl/KJNbY>

Comprehension Instructional Sequence Template.pdf

<http://goo.gl/xHMLM>

Just Read Florida: Comprehensive Instructional Sequence

<http://www.justreadflorida.com/pdf/CIS-Brochure.pdf>

## Close Reading

Close reading is a process that involves reading and rereading multiple times, each time with a different purpose and focus. It is a very specific examination, using attentive reading, to discover fine details within a text. For some students, this examination may require teachers to break text into smaller segments. If the text is short, the entire text lends itself to a close read. If, however, the text is lengthy, the teacher may select specific text segments for a close read and then relate those segments to the whole work.

Florida Standards emphasize the identification of strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

### Sample Focus Questions in a Scientific Inquiry

- How large was the sample size?
- How was the study conducted?
- Data: Are there tables and graphs?
- What did the study conclude?
- What could be the next step in the experiment or study?

### What Are the Benefits?

- Students understand the purpose in reading
- Students cite specific textual evidence
- Students see the interconnectedness that ideas in a text have

- Students summarize complex concepts
- Students look for and understand systems of meaning
- Students engage in a text while reading
- Students get beyond “surface” reading or skimming
- Students formulate questions and seek answers to the questions while reading

### **Online Resources on Close Reading**

The Art of Close Reading

<http://www.criticalthinking.org/pages/critical-thinking-the-art-of-close-reading-part-one/509>

How to do a Close Reading

<http://www.fas.harvard.edu/~wricntr/documents/CloseReading.html>

Close Reading of a Scientific Article, A Guide

<http://twp.duke.edu/uploads/assets/cclose.pdf>

### **Socratic Seminar**

A Socratic Seminar fosters active learning as participants explore and evaluate the ideas, issues, and values in a particular text. Socratic Seminar texts are chosen for their richness in ideas, issues, values and their ability to stimulate extended, thoughtful dialogue. A good text raises important questions in the participants' minds for which there are no right or wrong answers. At the end of a successful Socratic Seminar, participants often leave with more questions than they brought with them.

A Socratic Seminar opens with a question either posed by the leader or solicited from participants as they acquire more experience in seminars. An opening question has no right answer, but reflects a genuine curiosity on the part of the questioner. A good opening question leads participants back to the text as they speculate, evaluate, define, and clarify the issues involved. Response to the opening question generates new questions from the leader and the participants, leading to new responses in a cyclic fashion.

In a Socratic Seminar, the leader plays a dual role as leader and participant. The seminar leader consciously demonstrates habits of mind that lead to a thoughtful exploration of the ideas in the text by keeping the discussion focused on the text, asking follow-up questions, helping participants clarify their positions when arguments become confused, and involving reluctant participants while restraining their more vocal peers. As a seminar participant, the leader must know the text well enough to anticipate varied interpretations and recognize important possibilities in each. The leader must also be patient enough to allow participants' understandings to evolve and be willing to help participants explore non-traditional insights and unexpected interpretations.

Participants carry the responsibility for the quality of the seminar. Good seminars occur when participants study the texts closely in advance, listen actively, share their ideas and questions in response to the ideas and questions of others, and search for evidence in the text to support their ideas. After each seminar, the leader and participants discuss the experience and identify ways of improving the next seminar. Before each new seminar, the leader also offers coaching and practice in specific habits of mind that improve reading, thinking, and discussing. Eventually, when participants realize that the leader is not looking for right answers, but is encouraging them to think aloud and to exchange ideas openly, they discover the excitement of exploring important issues through shared inquiry. This excitement creates willing participants, eager to examine ideas in a rigorous, thoughtful manner.

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## Online Resources on Socratic Seminars

Socratic seminars in science class

<http://trice25.edublogs.org/2010/07/20/socratic-seminars-in-science-class/>

Using Socratic Seminars to Enhance Science Discussions

<http://socraticseminars.homestead.com/index.html>



## **Engineering Design**

Engineering design is defined as a systematic practice for solving problems as the result of that specific practice. According to the *NGSS Framework*: “From a teaching and learning point of view, it is the iterative cycle of design that offers the greatest potential for applying science knowledge in the classroom and engaging in engineering practices” (NRC 2012, pp. 201-2). The *NGSS Framework* recommends that students learn how to engage in engineering design practices to solve problems in science as early as elementary school.

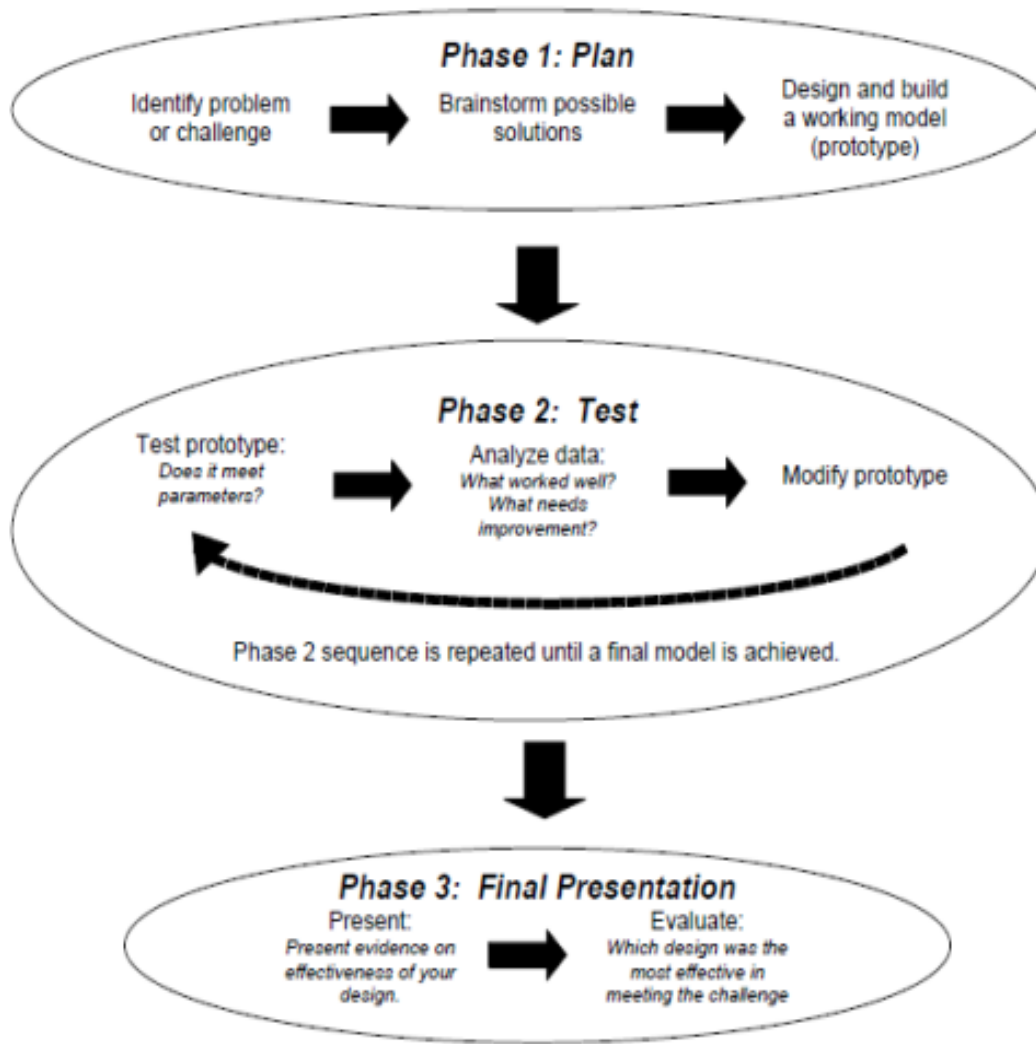
By the time these students leave high school, they can “undertake more complex engineering design projects related to major global, national, or local issues” (NRC, 2012, p. 71).

The core idea of engineering design includes three component ideas: (*NGSS Framework, 2011*)

- **Defining and delimiting engineering problems** involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits.
- **Designing solutions to engineering problems** begins with generating a number of different possible solutions, and then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.
- **Optimizing the design solution** involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.

“We anticipate that the insights gained and interests provoked from studying and engaging in the practices of science and engineering during their K-12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change.” (NRC 2012, p. 9).

## Engineer/Design Challenge Process



### Online Resources on Engineering Design

Engineering Design in NGSS

[http://www.nextgenscience.org/sites/ngss/files/Appendix%20I%20-%20Engineering%20Design%20in%20NGSS%20-%20FINAL\\_V2.pdf](http://www.nextgenscience.org/sites/ngss/files/Appendix%20I%20-%20Engineering%20Design%20in%20NGSS%20-%20FINAL_V2.pdf)

The Tech Museum, Design Challenge Lessons

<http://www.thetech.org/educator-resources/design-challenge-lessons>

eGDI Dream up the future

<http://teachers.egfi-k12.org/lesson-engineering-design-process/>

TryEngineering, Lesson Plans

<http://www.tryengineering.org/lesson.php>



## Problem Based Learning (PBL)

Problem-based learning has been shown to improve learning by requiring students to perform on a higher cognitive level. The use of PBL encourages students to learn through the process of inquiry in response to a question, problem or challenge.

PBL is a learning strategy in which the learner constructs meaning based on experiences guided and/or facilitated by the teacher. A lesson begins with a question or problem, provided and explained by the teacher. Students, (typically in cooperative groups) decide on a strategy for resolution of the problem. Depending on the mix of students, the teacher may provide varying levels of support for the student groups. PBL lessons may take a class period, a week, a semester, or longer, and will usually end with a culminating activity or a reflection to provide closure for the learning.

### Online Resources on Problem Based Learning

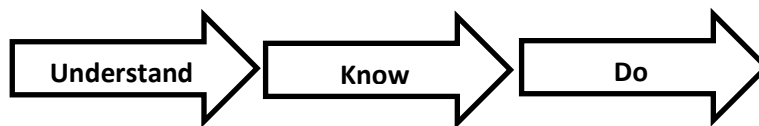
Problem-based Learning, PBL Science Sample Lesson  
<http://www.pblearning.com/science-sample-lessons.html>

Problem-based Learning in Science  
<http://www.cct.umb.edu/pblscience.html>

BIE, Project Based Learning for the 21<sup>st</sup> Century  
[http://www.bie.org/about/what\\_is\\_pbl/](http://www.bie.org/about/what_is_pbl/)

## Know, Understand, Do (KUD)

KUDs are learning goals that guide curriculum development, frame lessons or units, and anchor the assessments and learning activities. The writing of KUD statements help the teacher guide and focus learning during instruction. Teachers can create KUD statements at the standard, lesson or unit level. The degree of detail of the KUD is based on the scope of the selected activity.



- Know
  - KNOW statements describe key ideas and practices.
  - This information is the focus of the lesson(s) and ties back to the standards.
  - Students must know this information in order to understand, make connections and apply the knowledge of the discipline.
- Understand
  - UNDERSTAND statements are the essential truths of the discipline.
  - These statements organize knowledge in a way that assists students in applying that knowledge to the world around them.
  - UNDERSTAND statements may be revisited throughout multiple lessons in order to reinforce the essential truths.
- Do
  - DO statements are the expression of the students' understanding and proficiency.
  - Students must be able to demonstrate their knowledge and skills.
  - DO statements begin with a verb. This verb can be changed to increase cognitive complexity. (Bloom's Taxonomy/Webb's Depth of Knowledge)

## **Online Resources on Know, Understanding and Do**

Differentiation.com: What are KUDs?

<http://differentiationcentral.com/examples/SampleKUDs.pdf>

Differentiation.com: Clear Learning Goals

<http://differentiationcentral.com/examples/UnderstandingKUDs.pdf>

## **Argument Driven Inquiry (ADI)**

Argument-Driven Inquiry is focused on helping students learn important science content, practices, and habits of mind by engaging them in more authentic experiences.

The ADI instructional model is designed to:

- Establish a goal of a laboratory experience as an effort to develop, understand, or evaluate a scientific explanation for natural phenomena.
- Engage students in meaningful inquiry using methods of their own design.
- Encourage individuals to learn how to generate an argument that articulates and justifies an explanation for an essential question as a result of the inquiry process.
- Provide opportunities for students to learn how to propose, support, evaluate, and revise ideas through discussion and in writing.
- Produce a teaching environment which teaches students to value evidence, critical thinking, skepticism, and new ideas or ways of thinking.

## **Online Resources on Argument-Driven Inquiry**

Argument-Driven Inquiry: Instructional Model

<http://adi.lsi.fsu.edu/instructional-model>

ADI-Argument-Driven Inquiry

<http://www.argumentdriveninquiry.com/>

## **Graphic Organizers**

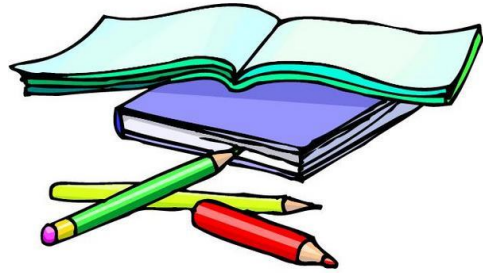
In order to make connections between topics, teachers and students may transfer abstract concepts and processes into visual representations. The use of concept maps and thinking maps helps students visualize concepts.

### **How Do You Use It?**

- The teacher provides a specific format for learning, recalling, and organizing.
- Students visually depict outcomes for a given problem by charting various decisions and their possible consequences.
- The teacher selects a main idea and then the teacher and students identify a set of concepts associated with the main idea, concepts are ranked in related groups from most general to most specific, related concepts are connected and the links labeled.
- Students structure a sequential flow of events, actions, roles, or decisions graphically on paper.

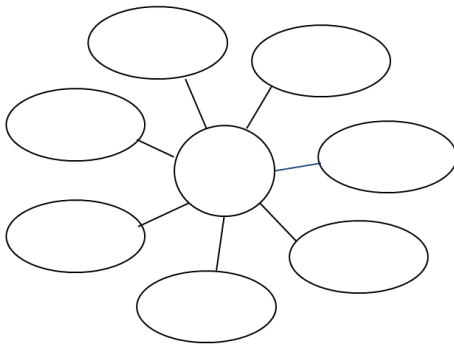
## What Are the Benefits?

- Helps students visualize abstract concepts
- Helps learners organize ideas
- Provides a visual format for study
- Develops the ability to identify details and specific points
- Develops organizational skills
- Aids in planning
- Provides an outline for writing

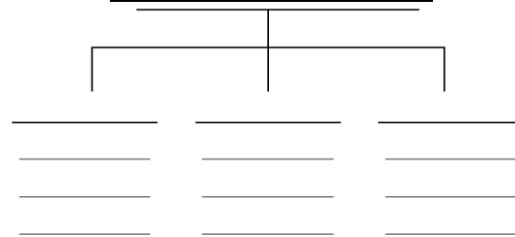


## Samples of Graphic Organizers

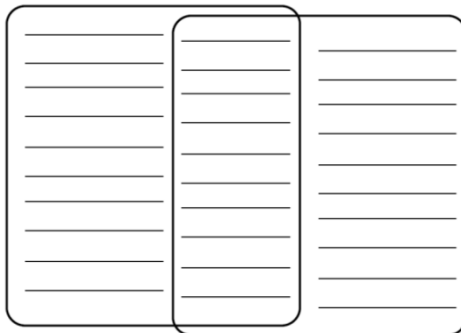
Bubble Map/Describing Qualities



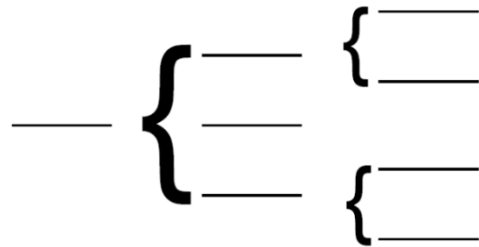
Tree Map/Classifying



Modified Venn Diagram\Comparing



Bracket Map\Whole to Parts



## Online Resources on Graphic Organizers

Examples of graphic organizers:

<http://www.ncrel.org/sdrs/areas/issues/students/learning/lr1grorg.htm>

Graphic Organizers that Support Specific Thinking Skills

<http://www.somers.k12.ny.us/intranet/skills/thinkmaps.html>

Instructional Strategies Online: comparing thinking maps and graphic organizers

<http://olc.spsd.sk.ca/DE/PD/instr/strats/graphicorganizers/index.html>

## **Model**

A scientific model is a representation of a concept. It may be concrete, such as a ball and stick model of an atom, or abstract like a model of weather systems. Models can be physical, mathematical, or computer based. They can be used to simulate systems and interactions involving energy, matter and information flows.

### **How Do You Use It?**

Students create a product that represents an abstract idea or a simplified representation of an abstract idea.

### **What Are the Benefits?**

- Models facilitate understanding of conceptual ideas.
- Models reinforce the value and use of models in science

## **Interactive Notebooks**

The interactive notebook provides an opportunity for students to be creative, independent thinkers and writers. Interactive notebooks can be used for a variety of purposes; such as class notes, expression of ideas and laboratory data. Requirements vary from teacher to teacher and are set up according to the directions of the teacher. Florida Standards construct a strong foundation for experiencing the process of scientific inquiry, which includes research, communication, written analysis and formal presentation of results and conclusion.

### **How Do You Use It?**

Interactive notebooks can be used to help students develop, practice, and refine their science understanding, while also enhancing reading, writing, mathematics and communication skills.

### **What Are the Benefits?**

- Students use visual and linguistic intelligences
- Notebooks help students organize their learning
- Notebooks are a portfolio of individual learning

## **Online Resources on Interactive Notebooks**

What is a science interactive notebook?

[http://jyounghewes.tripod.com/science\\_notebooks.html](http://jyounghewes.tripod.com/science_notebooks.html)

Science Notebooks in k-12 Classrooms

<http://www.sciencenotebooks.org/>

## **Dialogue Journals**

Dialogue Journals are a learning strategy in which students use interactive notebooks as a way to hold a private conversation with the teacher. Dialogue journals are a vehicle for sharing ideas and receiving feedback through writing.

### **How Do You Use It?**

Students write on science topics on a regular basis and the teacher responds with advice, comments, and observations in a written conversation. NOTE: It should be clearly communicated that this is not a diary, and should not be used to discuss personal issues.

### **What Are the Benefits?**

- Develops communication and writing skills
- Creates a positive relationship between the teacher and the student
- Increases student interest and participation
- Allows the student to direct his or her own learning

### **Learning Log**

The use of a Learning Log as a strategy is used to develop structured writing.

#### **How Do You Use It?**

During different stages of the learning process, students respond in written form under three columns: “*What I Think*”, “*What I Learned*”, “*How My Thinking Has Changed*”.

#### **What Are the Benefits?**

- Bridges the gap between prior knowledge and new content
- Provides a structure for translating concepts into written form

### **Critical Thinking Skills**

"Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Scriven, 1996).

#### **How Do You Use It?**

- Students should be able to relate issues or content to their own knowledge and experience
- Students should compare and contrast different points of view

#### **What Are The Benefits?**

- Student raises vital questions and problems, formulating them clearly and precisely
- Students gather and assess relevant information on an issue
- Students use abstract ideas to come to conclusions and solutions and analyze them against relevant criteria and standards
- Students think open-mindedly within alternative systems of thought, recognizing and assessing, as need be, their assumptions, implications, and practical consequences
- Student communicates with others in determining solutions to complex problems

### **Online Resources on Critical Thinking Skills**

Critical Thinking Skills in Education and Life

<http://www.asa3.org/ASA/education/think/critical.htm#critical-thinking>

Defining Critical Thinking

[http://www.criticalthinking.org/aboutct/define\\_critical\\_thinking.cfm](http://www.criticalthinking.org/aboutct/define_critical_thinking.cfm)

Teaching Critical Thinking Skills

<http://academic.udayton.edu/legaled/CTSkills/CTskills01.htm>

Critical Thinking: What It Is and Why It Counts

[http://www.insightassessment.com/pdf\\_files/what&why2007.pdf](http://www.insightassessment.com/pdf_files/what&why2007.pdf)

## Collaborative Learning

Collaborative learning strategies are strategies in which students work together in small groups to achieve a common goal. Collaborative learning involves more than simply putting students into work or study groups. Teachers promote individual responsibility and positive group interdependence by making sure that each group member is responsible for a given task. Collaborative learning can be enhanced when group members have diverse abilities and backgrounds.



### How Do You Use It?

After organizing students into carefully selected groups, the teacher thoroughly explains a task to be accomplished within a time frame. The teacher facilitates the selection of individual roles within the group and monitors the groups, intervening only when necessary, to support students working together successfully and accomplishing the task.

### What Are the Benefits?

- Fosters interdependence and pursuit of mutual goals and rewards
- Develops communication and leadership skills
- Increases the participation of shy students
- Produces higher levels of student achievement, thus increasing self-esteem
- Fosters respect for diverse abilities and perspectives

### Online Resources on Collaborative Learning

The Essential Elements of Cooperative Learning in the Classroom. ERIC Digest.  
<http://www.ericdigests.org/1995-1/elements.htm>

Competitive vs. Cooperative Learning Formats  
<http://www.behavioradvisor.com/CoopLearning.html>

## Reflective Thinking

A learning strategy in which students reflect on what was learned.

### How Do You Use It?

Approaches to reflective thinking may include students writing a journal about the concept learned, comments on the learning process, questions or unclear areas, and interest in further exploration.

### What Are the Benefits?

- Helps students assimilate what they have learned
- Helps students connect concepts to make ideas more meaningful

*It is the supreme art of the teacher to awaken joy in creative expression and knowledge.*

Albert Einstein



## Multi-tiered Systems of Support MTSS

Multi-tiered Systems of Support are a comprehensive, standards-aligned strategy to enable early identification and intervention for students at risk. Key items include alignment of standards to instruction, universal screening, shared ownership; data based decision making, and parental involvement. MTSS allows educators to identify and address academic difficulties prior to student failure. MTSS's goal is to improve student achievement using research-based interventions matched to the level and instructional needs of students.

### Online Resources for Multi-tiered Systems of Support

Florida's Multi-tiered Systems of Support (MTSS) website provides a central, comprehensive location for Florida-specific information and resources that promote school wide practices to ensure highest possible student achievement in both academic and behavioral pursuits.

<http://www.florida-rti.org/>

Implementing a Multi-Tiered System of Support for Behavior: Recommended Practices for School and District Leaders in Florida

[http://flpbs.fmhi.usf.edu/pdfs/RTIB%20Guide%20101811\\_final.pdf](http://flpbs.fmhi.usf.edu/pdfs/RTIB%20Guide%20101811_final.pdf)

## Continuous Quality Improvement (CQI)

Continuous Quality Improvement (CQI) provides an opportunity to make assessment more meaningful. Traditional assessment sometimes produces a false record of student achievement. For example, if a student were to earn a series of test grades, such as 30%, 60%, 95% and 100%, the student has apparently improved in mastery of the material. Yet, the average would be 71%. This does not demonstrate that mastery was achieved and would actually be an unsatisfactory grade average. CQI might more truly reflect a student's knowledge base. Its results can be rewarding for students and teachers.

- With a specific set of criteria established prior to the assignment, the student knows what the expectations of success are. The criteria may be designed by both the teacher and student.
- If the criteria are met, the student will then earn a "Q" for Quality; if not, a "NY" for Not Yet Quality.
- The student may repeat the assignment at the instructor's discretion until "Quality" is achieved.
- The student is not penalized for not achieving quality immediately.
- All students have the opportunity to succeed.

### How to transfer CQI to traditional grade sheets

A teacher can convert "Q's" and "NY's" to letter grades. The teacher counts the number of assignments and divides them into 100. For example, if a teacher gave ten (10) assignments, they would be worth ten points apiece. To weight a major assignment more heavily, assessments in multiple categories may be recorded.

A sample format follows:





Research Paper	(Quality 10 points)
Presentation: Research	(Quality 10 points)
Presentation: Visual Aid	(Quality 10 points)
Presentation: Creativity	(Quality 10 points)
Lab Performance 1	(Quality 10 points)
Lab Performance 2	(Quality 10 points)
Discussion	(Quality 10 points)
Problem-Solving Activities	(Quality 10 points)
Unit Quiz	(Quality 10 points)
Journal	(Quality 10 points)

In the example above each assignment is worth 10 points. If quality is achieved, then the total of 10 would be given. If a “NY” is given and never reworked, then 2-9 points are earned, depending on the quality of the work submitted. If the assignment is not done, then a 0 would be earned. A scale of 100 would be used to compute a percentage.

### **Online Resource Continuous Quality Improvement (CQI)**

#### **A New Alliance: Continuous Quality and Classroom Effectiveness**

<http://www.ntlf.com/html/lib/bib/94-6dig.htm>

### **Assessments Forms**

Educational assessment is the process of documenting, in measurable terms, learned knowledge and skills. Assessment can focus on the individual learner, the learning community, the institution, or the educational system. Progress monitoring is a scientifically based practice that is used to assess students' academic performance and evaluate the effectiveness of instruction. Progress monitoring can be implemented with individual students or an entire class.

### **Progression Scales (Proficiency Scales)**

Progression Scales are clear learning goals that positively impact student learning. They must be understandable to students (unlike "standards", which are written for educators) and measurable by the student and the educator. Research by Marzano (The Art and Science of Teaching: A Comprehensive Framework for Effective Instruction, 2007) has shown that the establishment of clear learning goals positively impacts student learning. These progression scales must establish specific criteria that are appropriately sequenced and directly support the learning goal. They must be clear and measurable so that both students and teachers can track learning progress. The Marzano Research Laboratory has established the use of proficiency scales as a means of supporting effective implementation of the Florida Standards.

A progression (proficiency) scale template and sample science scales can be downloaded free from <http://www.marzanoresearch.com/resources/proficiency-scale-bank> . (Free registration with Marzano Research Laboratory is required to access the bank.)

### **Diagnostic Assessment**

Diagnostic assessment is given before instruction. This assessment determines student understanding of topics before learning takes place. Diagnostic assessment provides a way for teachers to plan, or map out a route, using students' existing knowledge to build upon. It also allows for identification of gaps or misconceptions in prior learning.

**Examples:** Diagnostic content specific tests & surveys

## **Formative Assessment**

Formative assessments are given during the instructional unit, and the outcomes are used to adjust teaching and learning. They provide many opportunities for students to demonstrate mastery of identified goals. Formative assessments should vary to accommodate students' habits of minds to demonstrate knowledge.

**Examples:** Homework  
Questioning during instruction  
Thinking Maps  
Interactive Notebooks  
Formative Assessment Probes

## **Interim Assessment**

Interim Assessments are administered during an interval of instruction, such as at the end of a or multiple times in a course. Interim tests fall between summative and formative assessments. Interim assessments administered during instruction that are designed to evaluate students' knowledge and skills relative to a specific set of goals to inform decisions in the classroom and beyond.

**Examples:** End of Unit Exams  
Periodic exams during the school year

## **Summative Assessment**

Summative assessments are given at the end of instructional units and can be used to determine final judgment about student achievement and instructional effectiveness.

**Examples:** End of Course Exams  
AP, AICE and IB Exams

## **Online Resources for Diagnostic, Formative, Interim and Summative Assessment**

Teacherness Empowering Teacher: Interim Assessments  
<http://www.teacherness.com/resources/articles/69-what-is-interim-assessment.html>

Assessment-Inquiry Connection  
<http://www.justsciencenow.com/assessment/index.htm>

Assessment and Evaluation  
<http://www.icc.edu/innovation/PDFS/assessmentEvaluation/ASSESSMENTandEVALUATION2007.pdf>

**Diagnostic, Formative & Summative Assessments – What's the difference?**  
<http://blog.learningtoday.com/blog/bid/20323/Diagnostic-Formative-Summative-Assessments-What-s-the-difference>

## **Performance Assessment**

Knowledge and understanding are tightly linked to the development of important process skills such as observing, measuring, graphing, writing, and analyzing. The teacher can assess such skill development by observing student performance. Many science teachers have experience with performance assessment through the use of a lab practical.

Performance assessment can include models, drawings, stories, multimedia presentations, and any other objects by which students demonstrate what they know. Models and drawings allow students to use tactile skills to represent ideas, feelings, structures, or concepts. Oral and dramatic presentations help students with public speaking skills and reinforce their own knowledge and that of the audience. Whenever possible, other classes, the community, and families could be invited to participate in the presentations.

The variety of products and projects that students may produce is immense. The following are examples of products and projects:

- produce a podcast
- recreate a famous experiment
- build a model
- create a movie
- develop a guide
- design a simulation
- design a scientific investigation (inquiry)

It is important to note that developing scoring guidelines for performance assessment requires careful analysis of student responses to accurately assess performance levels.

### **Online Resource for Performance Assessment**

#### **LESSONPLANET Science Performance Assessment**

<http://www.lessonplanet.com/article/elementary-science/science-performance-assessment>

## **Rubrics**

The term *rubric*, rather than scoring key, is used to refer to the guidelines laid out on performance-based tasks. Rubrics spell out in detailed language what learning is expected and the standard for products and performances. Rubrics are designed for reporting results, scoring, and coaching students to a higher level of performance. Furthermore, because rubrics are determined in advance, they provide clarity of focus for students and teachers. Rubrics are also helpful tools in increasing student competencies in the areas of self-management, peer assistance, and self-evaluation.

### **Developing a Rubric**

Building a rubric is an ongoing process. Rethinking, refining, and rewriting are a part of the process. Students, teachers, parents, and others can offer valuable insight and objectivity. It is important to have a purpose for the rubric and to be certain that the rubric supports that purpose.

- Determine which concepts, skills, or performance standards you are assessing.
- List the concepts and rewrite them into statements which reflect both cognitive and performance components.
- Identify the most important concepts or skills being assessed in the task.
- Based on the purpose of your task, determine the number of points to be used for the rubric example: 4-point scale or 6-point scale.
- Based on the purpose of your assessment, decide if you will use an analytic rubric or a holistic rubric.
- Starting with the desired performance, determine the description for each score remembering to use the importance of each element of the task or performance to determine the score or level of the rubric.
- Compare student work to the rubric. Record the elements that caused you to assign a given rating to the work.

- Revise the rubric descriptions based on performance elements reflected by the student work that you did not capture in your draft rubric.
- Rethink your scale: Does a 6-point scale differentiate enough between types of student work to satisfy you?
- Adjust the scale if necessary. Reassess student work and score it against the developing rubric.

**Analytic rubric vs. Holistic rubric:**

**Analytic:** Assigning separate scores for different traits or dimensions of a student’s work. The separate score should total your predetermined amount.

**Holistic:** Assigning one overall score based on the combination of performance standards being assessed.

**Sample Rubrics for Student Products, Projects, and Problem Solving**

**Does the product reflect that the student made valid inferences from data sources?**

- 4= The product reflects that the student made valid inferences from data sources.
- 3= The product reflects that the student made invalid inferences from data sources.
- 2= The product lacks inference from data sources.
- 1= The product lacks evidence that the student used data sources.

**Does the product show evidence that the student reached valid conclusions based on data analysis and displayed the results of the analysis in appropriate formats e.g. graphs, charts, tables, pictures, and other representations?**

- 4 = The product shows evidence that the student reached valid conclusions based on data analysis and displayed the results of the analysis in appropriate formats.
- 3 = The product shows evidence that the student reached valid conclusions based on data analysis and displayed the results of the analysis in inappropriate formats.
- 2 = The product shows evidence that the student reached conclusions not based on data analysis and displayed the results of the analysis in appropriate formats. **OR** the product shows evidence that the student reached valid conclusions based on data analysis but lacked evidence of the analysis.
- 1= The product shows no evidence of data analysis.

*A teacher who is attempting to teach without  
inspiring the pupil with a desire to learn is  
hammering on cold iron.*

Horace Mann

## A Sample Laboratory Rubric

### Phase Change Assessment

**Task:** This is a three-day activity in which students observe and perform a distillation to demonstrate phase change, explain energy transformation, and identify key components in the system. On day one, a group of students writes a description of the distillation equipment that is placed in a location that the other class members cannot see. The rest of the class assembles the lab equipment on the lab tables according to this description. On day two, the lab groups use the setup to experiment with the phase change of water from liquid to gas and back to liquid. Each group writes their own statement of the problem, hypothesis, procedure, data table, and conclusion. On day three, each student describes individual components of the setup and explains how each part is used to cause water to change phases.

### Rubric

Topics	Score 4	Score 3	Score 2	Score 1
<b>Collaborative Worker:</b> Student can take charge of his/her own behavior in a group	Student stays on task; offers useful ideas and can defend them; can take on various roles; participates without prompting.	Student stays on task; offers useful ideas and can defend them; can take on various roles; rarely requires prompting to participate.	Student does not attend to the lab. Student accepts group view or considers only his/her own ideas worthwhile. Student needs regular prompting to stay on task.	Student does not respond to the group. Student is not involved or may try to undermine the efforts of the group.
<b>Scientific Literacy:</b> Student uses processes and skills of science to conduct investigations	Student identifies the question, forms a possible solution, designs a data chart, collects data, and concludes about the validity of the possible solution.	Student identifies the question, forms a possible solution. Procedure and data chart are complete but lack clarity and/or creativity. Student concludes about the validity of the possible solution.	Student identifies the question but does not form a complete solution. Procedure and data are incomplete and the conclusion does not speak to the possible solution.	Student does not identify the question. No possible solution is given. Procedure and data chart are incomplete or missing. The conclusion is incomplete or missing.
<b>Systems Analysis:</b> Student describes how a system operates internally and how it interacts with the outside world.	Student identifies how parts of the system interact and provides personal insight into the interacting of the parts. Student relates how the system interacts with the outside world.	Student identifies how parts of the system interact and relates how the system interacts with the outside world.	Student does not identify some parts of the system. Student does not understand how the parts interact and does not relate how the system interacts with the outside world.	Student incorrectly identifies the parts and cannot describe how they interact either within or outside the system.

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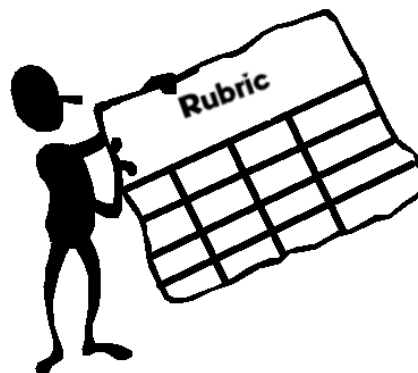
### Online Resources for Rubrics

Rubrics

<http://www2.gsu.edu/~mstnrhx/457/rubric.htm>

Rubrics for Assessment

<http://www.uwstout.edu/soe/profdev/rubrics.cfm>



## **Inquiry Based Labs to Assess Learning**

Inquiry based labs are exploration activities in which students are responsible for all aspects of the experimental design. Students must demonstrate sufficient content, process, and safety readiness before they are permitted to proceed in order to ensure a safe and meaningful laboratory experience. Assessing inquiry activities requires teachers to recognize that not all students will choose to explore the same aspect of a given problem. Students should be able to explain and justify their procedure.

Evaluation may be based on:

- reasoning skills
- the ability to identify the question
- the experimental design
- documentation of data
- drawing conclusions from data
- teamwork

### **Online Resources for Inquiry Based Labs**

NSTA National Association of Science Teacher Position Statement Scientific Inquiry  
<http://www.nsta.org/about/positions/inquiry.aspx>

Inquiry Based Approaches to Science Education: Theory and Practice  
<http://www.brynmawr.edu/biology/franklin/InquiryBasedScience.html>

Mini-Labs.org: Inquiry-Based Lab Activities for Formative Assessment  
[http://www.mini-labs.org/Mini\\_Labs\\_Home.html](http://www.mini-labs.org/Mini_Labs_Home.html)

## **Interactive Notebooks to Assess Learning**

An interactive notebook is a student's record of activities and reflections. Interactive notebooks are dynamic assessment tools that promote communication between the teacher and student, reflection on what students are learning and active involvement in classroom activities.

Interactive notebooks can also be used to assess attitudes toward science. To realize the full potential of the interactive notebook, the teacher should probe, challenge, or ask for elaborations about the entries submitted.

Assessment of interactive notebooks depends on the purpose of the interactive notebook and the maturity of the student. The act of keeping an interactive notebook can be considered a goal in itself if a teacher wants the students to structure or feel ownership of their own learning, and the criterion for success of this objective might simply be the completion of the assigned interactive notebook entries.

## Open-Ended Questions

Open-ended questions are highly compatible with the current emphasis on teaching students to become active complex thinkers and effective communicators.

Open-ended questions can assess a variety of instructional goals, including:

- conceptual understanding
- application of knowledge via creative writing
- the use of science process skills, and divergent thinking skills

If open-ended questions are to be included on a test that will be graded, it is important that teachers prepare students for expectations that may be new to them. Student anxiety over open-ended test questions might be reduced by sharing examples of model student responses and providing opportunities for practice.

Grading open-ended questions involves interpreting the quality of the response in terms of predetermined criteria. Several suggestions for rating open-ended questions are offered below:

- Determine in advance the elements expected in an answer.
- Communicate the criteria that will be assessed.
- Read a sampling of answers before assigning grades to get an idea of the range of responses to each question.

Some suggestions for open-ended questions that lead to higher order-thinking are listed below:

- What is the relationship between...?
- How might this principle be applied to...?
- What are some of the limitations of the data?
- How might this information be used in another area?

## Portfolios

Portfolios refer to the process of assessing student progress by collecting examples of student products. Physically, it is a container of evidence of a student's achievements, competencies, or skills. It is a purposeful collection in the sense that the collection is meant to tell a story about achievement or growth in a particular area. Portfolios represent complex, qualitative, and progressive pictures of student accomplishments.

The use of portfolios, like any assessment method, starts with a consideration of purposes. A properly designed assessment portfolio can serve four important purposes. It allows:

- teachers to assess the growth of students' learning
- students to keep a record of their achievements and progress
- teacher and parents to communicate about student work, and/or
- teachers to collaborate with other teachers to reflect on their instructional programs

An essential step for determining what to include in a portfolio is to answer the question: *What should students know and be able to do?* This establishes criteria by which the quality of a task is judged. A portfolio may include, but is not limited to:

- a table of contents
- a description of the concepts to be mastered

- artifacts that demonstrate the student’s mastery of concepts
- evidence of self-reflection
- a series of work samples showing growth over time
- examples of best work
- assessment information and/or copies of rubrics
- progress notes contributed by student and teacher collaboratively

A portfolio may be as simple as a large expandable file folder in a place that is easily accessible to students and teacher. The location invites student and teacher contributions on an ongoing basis. It is important for students to review their portfolios to assess what they have achieved. It is in self-reflection that the student realizes progress and gains ownership in learning and achievement.

### **Graphic Organizers as Assessment Tools**

Graphic organizers can be used as effective assessments as well as teaching strategies. A graphic allows students to organize large amounts of information in a limited space, usually one page. Student-developed graphic organizers can be used to demonstrate how well students have grasped concepts and connected ideas.

Examples of graphic organizers include concept maps, thinking maps, diagrams, word webs, idea balloons, and Venn diagrams.

### **Integrating Technology in Assessment**

The use of technology can play a vital role in student achievement and assessment. Teachers need to assess students’ learning/instructional needs to identify the appropriate technology for instruction. Technology materials need to be reviewed in order to determine their most appropriate instructional use. Research based practices should be applied in the integration of instruction and assessment. Select and use appropriate technology to support content-specific student learning outcomes. When developing assessments with the use of technology they should be appropriate to student outcomes.

Examples of technologies that can be used in the classroom to facilitate assessment:

- Edline
- Computers/Computer Software
- Internet
- Laboratory Probes
- Still and Video Cameras
- Classroom Response Systems
- Question Data Banks

### **Online Resources for Integrating Technology in Assessment**

Technology Integration, Technology in Schools: Suggestions, Tools, and Guidelines for Assessing Technology in Elementary and Secondary Education [http://nces.ed.gov/pubs2003/tech\\_schools/chapter7.asp](http://nces.ed.gov/pubs2003/tech_schools/chapter7.asp)

Motivate While You Integrate Technology: Online Assessment  
[http://www.educationworld.com/a\\_tech/tech/tech125.shtml](http://www.educationworld.com/a_tech/tech/tech125.shtml)



## Assessment Interview

In an interview, the teacher questions students individually about learning. A series of probing questions can be developed that are useful in deciding how to help students improve their performance.

Many benefits can result from interviews:

- Rapport is encouraged and student motivation may be increased.
- Students who are intimidated by written tests may express what they understand in a less threatening context.
- Interviews provide teachers the opportunity to probe and ask follow-up questions in ways that challenge students to think beyond their current level of understanding and to organize their knowledge in more systematic ways.

Some suggestions for effective interviewing follow:

- Keep the tone of the interview positive and constructive. Remember to avoid giving verbal cues or exhibiting facial expressions that can be interpreted as meaning that an answer is incorrect.
- Let students respond without interruptions and give them time to think before they respond.
- Try to keep interviews short and focus on relevant questions.

## Peer Assessment

Peer assessment occurs every time students collaborate on assignments, explain their understanding of a topic to another, or ask their neighbor in class how to proceed with a lab experiment. Many times the most valued opinions and assessments are those students determine with one another.

Peer assessment requires students to put aside any biases toward each other and truly reflect on accomplishments. Procedures and criteria for peer assessment should be developed with the class. By assessing others' work, students often see alternative reasoning patterns and develop an appreciation for the diverse ways of approaching problems.

Some advantages of peer assessment are:

- increased quality of performance
- improved cooperative attitudes, and enhanced leadership skills

## Self-Assessment

Student self-assessment questionnaires are helpful in determining how students perceive their knowledge, skills, or the quality of their work. When used appropriately, self-assessments actively involve students in reflecting on their learning process and emphasize the importance of students' awareness about what they know and what they need to know.

Teachers may find it helpful to present a science self-assessment at the beginning, middle, and end of the school year to monitor student changes in attitudes towards science and their individual successes within a given class.

Students may be requested to include self-assessments as a part of project and portfolio assignments.

Groups or teams may be required to evaluate individual and group performance related to teamwork and responsibility and to make recommendations for improving group performance on future projects.

Students can be asked to evaluate their understanding of concepts at any point in the instructional process. A teacher might announce future topics, e.g., carbohydrates, starch, glucose, and digestion and ask students to rate each concept using the following key:

- 1 = I have never heard of it.
- 2 = I have heard of it but do not understand it.
- 3 = I think I understand it partially.
- 4 = I know and understand it.
- 5 = I can explain it to a friend.

Such an approach to assessing students' understanding is less threatening than a pre-test and can give students a sense of the different levels of knowledge, particularly if used frequently in a class situation. Results of student ratings of each concept could be tabulated as a class activity, which may promote positive peer interactions and expand learning opportunities.

## **Teacher Observation of Student Learning**

Some goals and objectives can only be assessed by observation. For example, it is difficult to imagine how a teacher would assess students' team problem-solving skills or success at independent lab work without observing them. The three types of teacher

### **Informal Observations**

Teachers regularly observe students and make assessments about their performance that influence future instruction. With informal observations, teachers observe with no predetermined focus. The information gathered may be used for parent or student conferences. Informal observations occur daily, and occasionally teachers may want to record information from their observations.

### **Structured Observations**

The components of structured observations include a specified focus and a sample behavior to be observed systematically. The information may be used to show which students need improvement or to give students feedback about how they are improving.

### **Narratives**

Progress on some objectives can be tracked best through narrative records of observed behavior. A narrative is a written record. Such narratives are particularly appropriate for complex behaviors, such as group interactions, which cannot be described effectively with a checklist.

For example, a teacher might observe and describe a cooperative team learning activity. Over time, a series of these narratives might demonstrate how students improved in working as a team.

*The formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill.*

*Albert Einstein*

## Quality Science for All Students

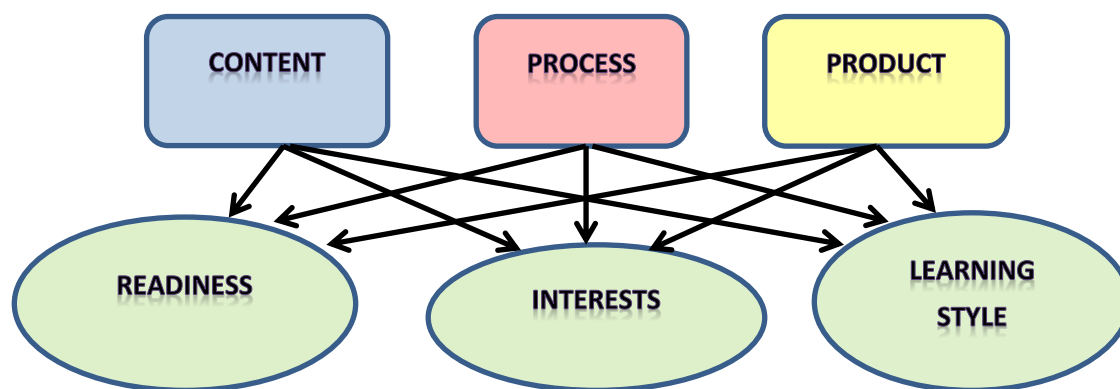
All students, not just a talented few, need to learn science. It is integral to all of society and provides a foundation for understanding the world in which we live. It is important that accessible opportunities for learning science are provided to every student.

Today and tomorrow are being shaped by science and technology. Our society is dependent on how wisely we use science and technology. It is necessary for students to develop the understanding and thinking habits they need to become informed citizens and prepared to face life head-on. Science and technology are so intertwined in society, that lack of “science literacy” may adversely impact our economy, our democracy, and our quality of life.

We have a mission to make science literacy possible for all students. What is required is a commitment to developing higher-order thinking and problem-solving skills. Science-literate citizens are better prepared to assume responsibilities for making our world a better place.

### Differentiated Instruction

Differentiating instruction means creating several paths that students at different levels of readiness, learning styles, and interests can be successful in learning.



One way to think about differentiated instruction is by using the framework of “content, process, and product:”

- Content – What you teach and expect the students to learn.
- Process – How you teach and expect the students to learn.
- Product – How you expect the students to demonstrate what they have learned.  
(Maryland Learning Links, <http://marylandlearninglinks.org/2015> )

### Online Resources Differentiated Instruction

Maryland Learning Links

<http://marylandlearninglinks.org/2015>

Differentiated instruction, Dr. Susan Allen

<http://differentiatedinstruction.net/>

Differentiate Your Science Lessons to Capture the Attention of Every Student

<http://differentiatedinstructionlessonplans.com/differentiated-science-lesson-plans>

Sunshine Connections, FLDOE

<http://www.sunshineconnections.org/strategies/Pages/DifferentiatedInstruction.aspx>

Enhance Learning with Technology

<http://members.shaw.ca/priscillatheroux/differentiating.html>

## Science Literacy

Science is an integral part of life and prepares students to make reasoned, thoughtful, and healthy lifelong decisions in a world that is constantly changing. Scientific literacy promotes skeptical, creative minds able to interpret data and to distinguish between scientific information and pseudoscience.

Exemplary science teachers relate what students already know to new concepts by building upon prior knowledge and working to identify and resolve students' misconceptions. They emphasize the real-life relevance of science, use examples that relate to daily life experiences, and encourage students to find connections to their own experiences. Current and varied resources are used to provide a variety of perspectives and up-to-date information, with an instructional focus on concepts rather than textbook chapters. Teachers ask probing questions that encourage student discussion, prediction, or explanation.

Students should be actively engaged in scientific processes and inquiry. They should collect, manipulate, and interpret data regularly, and use the data to answer questions or support claims. Predicting, inferring, and comparing are integral, adding to the student's depth of understanding.

**40% of science instruction time should be devoted to activities involving the manipulation, collecting and analyzing of data.**



## Matching Strategies to Course Level

Addressing the standard and honors course levels in science can prove challenging to teachers because the core content of the courses, as determined by the Florida Department of Education, may be similar. Differences may be defined by the level at which the students are asked to think, solve, explain, design, develop, and produce. It is important to remember that all students should have strong experience in each of the identified science standards, with an emphasis on science process skills. All students should have opportunities to pursue in-depth projects, experimental design, and original research. Higher level activities should comprise a significant percentage of the “honors” curriculum.

BLOOM'S TAXONOMY Revised)	WEBB'S DEPTH OF KNOWLEDGE
<b>Remembering</b> Define, duplicate, list, memorize, recall, repeat  Standard 10%, Honors 10%	<b>Level One - Recall</b> Recall of a fact, information, or procedure. Represent in words or diagrams a scientific concept or relationship. Conduct basic mathematical calculations.
<b>Understanding</b> Classify, describe, discuss, explain, identify, locate, recognize, select  Standard 30%, Honors 10%	
<b>Applying</b> Choose, demonstrate, dramatize, interpret, illustrate, interpret, solve  Standard 30%, Honors 20%	<b>Level Two -Basic Application of Skill/Concept</b> Use of information, conceptual knowledge, procedures, or two or more steps. Formulate a routine problem given data and conditions. Organize, represent and interpret data.
<b>Analyzing</b> Appraise, compare, contrast, criticize, examine, differentiate, discriminate, distinguish  Standard 10%, Honors 20%	<b>Level Three -Strategic Thinking</b> Requires reasoning, developing a plan or sequence of steps; has some complexity; more than one possible answer. Identify research question for a scientific problem. Think and process multiple conditions of the problem or task.
<b>Evaluating</b> Argue, defend, judge, support, value, evaluate, select  Standard 10%, Honors 20%	<b>Level Four - Extended Thinking</b> Requires an investigation. Create a mathematical model to inform and solve a practical or abstract situation. Conduct a project that requires specifying a problem, designing and conducting an experiment, analyzing its data, and reporting results/ solutions. Apply mathematical model to illuminate a problem or situation. Develop a scientific model for a complex situation. Student peer review.
<b>Creating</b> Assemble, construct, design, develop, formulate  Standard 10%, Honors 20%	

Sample “Standard” Questions/Activities	Sample “Honors” Questions/Activities
“What happened?” “Why do you think that occurred?” “Demonstrate how to do it.” “Build a working model.”	“Design a way to find out.” “Propose an alternative method.” “Create a more efficient solution.” “Defend your recommendation.”

## **Addressing Science Learning for Students with Special Needs**

Students with special needs may face an array of obstacles when learning science. There are a number of accommodations, changes in how a student is taught or tested, that a science teacher may use to help students make learning gains. These accommodations must not change the requirements the students must meet. There are several interventions, strategies used to help a student make progress in learning of behavior, which the teacher may use. Additional information may be found at: <http://ese.sp.brevardschools.org/default.aspx>

### **Strategies for Students with Attention Deficit Disorders (ADD/ADHD)**

#### **Establishing the Proper Learning Environment in Science**

- Seat students with ADD/ADHD closer to the teacher, but include them as part of the regular science class seating.
- Avoid distracting stimuli. Try not to place students with ADD/ADHD near air conditioners, high traffic areas, doors, or windows.
- Students with ADD/ADHD may require additional attention and assistance during field trips, labs and hands-on activities.
- Provide a quiet area in the classroom for use by any student wishing to reduce distractions.

#### **Giving Instructions in Science to Students with ADD/ADHD**

- Maintain eye contact when giving verbal science instruction.
- Simplify complex directions for science activities and avoid multiple commands.
- Confirm that students understand the instructions before beginning an activity or lab. Repeat instructions in a calm, positive manner, if needed.
- Help students feel comfortable in asking for assistance. Many students with ADD/ADHD will not ask for help.

#### **Giving Assignments in Science to Students with ADD/ADHD**

- Help the students develop and maintain an organizational system. (Organization is an important but difficult task for most ADD/ADHD students.)
- Modify science assignments as needed to match the quantity of work to the needs of the student.
- Give extra time for certain tasks. Students with ADD/ADHD may work slowly. Do not penalize them for needing extra time to complete an assignment or lab activity.
- Keep in mind that children with ADD/ADHD are easily frustrated. Stress, pressure, and fatigue can break down their self-control and lead to poor behavior.

#### **Providing Supervision and Discipline in Science**

- Assure that students clearly understand safety rules and requirements as well as potential hazards.
- Enforce classroom rules consistently.
- Administer consequences immediately, and monitor behavior frequently.
- Avoid ridicule and criticism. Remember that children with ADD/ADHD have difficulty staying in control.

#### **Providing Encouragement**

- Praise good behavior and performance.
- Encourage positive self-talk e.g., “You did very well remaining on task today. How do you feel about that?”. This encourages the child to think positively about themselves.
- Provide opportunities for students to focus their attention and energy in positive ways, such as distributing lab supplies to classmates or long term projects that involve data collection.

## **Strategies for Speakers of Other Languages**

The ELL (English Language Learners) student may face an array of obstacles when learning science. There are a number of strategies which may be useful in helping the student learn science while they are also learning English.

- The use of visuals is extremely helpful. Many science concepts can be addressed through demonstrations and hands-on activities. Any student, not just the LEP (Limited English Proficiency), can benefit from demonstrations and laboratory work. It may be necessary to provide the LEP with the laboratory procedure ahead of time, so the LEP can translate and thoroughly understand the task at hand. The use of visuals can also include labeling items within the classroom and allowing the LEP to match pictures, items, colors, and symbols with words.
- Pairing a struggling LEP student with a more accomplished one might assist both in their work.
- Cooperative learning is useful. It provides the LEP the opportunity to hear and practice the English language in a group setting.
- The use of gestures and facial expressions is effective in portraying meaning. Caution needs to be taken to ensure the gestures and expressions used are not offensive to the LEP).
- Encourage the LEP to ask questions to clarify understanding.
- Use repetition and consistency when giving instructions.
- Create word banks. Science has a unique vocabulary the LEP will not encounter out of the classroom. Supplying the LEP with important vocabulary ahead of time will allow the LEP to translate and have an understanding of the vocabulary before class. This will make a class discussion or lecture easier for the LEP to understand.
- Semantic Mapping is a strategy which uses vocabulary and background knowledge. The student can display words, ideas, and details that relate to a larger concept.
- A Native Language/English Dictionary should be made available. Make use of available science resources to make lessons relevant.
- Use musical activities to introduce and reinforce science concepts.
- Use graphic organizer strategies such as consequence diagrams, decision trees, flowcharts, Venn diagrams, and webbing to make the science concepts easier to understand.
- When assessing the LEP, it is helpful to allow the student additional time to complete the task. Another option is to use oral assessment. A visual exam could be used by having the student identify diagrams or depicts ideas and processes through diagrams.

## **Strategies for Teaching Science to Academically Gifted Students**

Gifted learners require an enhanced curriculum of instruction. The curriculum should have greater depth of study for greater challenge and complexity.

Depth of study and complexity can be increased by including the following:

- attributes, patterns and details
- connections between disciplines
- opportunities for questioning different points of view
- opportunities for promote thinking of different possibilities or solutions

General Characteristics - Gifted Students

- Gifted learners are diverse.
- Crave knowledge. Irresistible desire to learn certain subjects. Set high standards for themselves. Challenge generalizations.

- May be outstanding in some areas but average in others.
- Need to feel a sense of progress in what they are learning.
- Desire to know, have the capacity to create, structure, and organize data.
- Need to make observations, establish serial relationships, and comment on them.
- Have tremendous power of concentration.
- Are sensitive to values.
- Resist routines. Need time to work alone.
- Seek order, structure, consistency, and a better way of doing things.

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# Marine Science I Suggested Curriculum Course Pacing Guide

## Marine Science I

**Course Description and Standards can be found at the following link:**  
<http://www.cpalms.org/Public/PreviewCourse/Preview/4334>

This is a pacing guide that correlates with the textbook, *Marine Science, The Dynamic Ocean* by Schuster and Marrero for Marine Science. The purpose of the pacing guide is to recommend a sequence for addressing all the Marine Science I standards. As you look at the pacing guide, you will see a thematic approach, for example *Ocean Exploration* and the correlated lessons in the text, as well as standards, resource activities/labs, and essential questions (EQ). The marine science textbook selected for BPS has online support (refer to BSEND). Classroom Resources and ExamView Test Bank are also available on CD-ROM.

### Marine Science 1 Pacing Guide (Revised July 2014)

Thematic Lesson Sequence with Text References, Resources, and Essential Questions	Next Generation Sunshine State Standards & Florida Standards	Suggested Time
<p>The Florida Standards listed to the right should be integrated into all units of instruction throughout the year. Specific lessons are provided in the Appendix of this document.</p>	<p>LAFS.1112.RST.1.1,1.2, 1.3, 2.4, 2.5, 2.6, 3.7, 3.8, 3.9, 4.10</p> <p>LAFS.1112.SL.1.1, 1.2, 1.3, 2.4, 2.5</p> <p>LAFS.1112.WHST.1.1, 1.2, 2.4, 2.5, 2.6, 3.7, 3.8, 3.9, 4.10</p>	<p>On going</p>

<p><b><u>Ocean Exploration and Technology</u></b></p> <ul style="list-style-type: none"> <li>• The Nature of Science</li> <li>• Ocean Misconceptions and Discoveries</li> <li>• Human uses of the ocean throughout history</li> </ul> <p><i>Lesson 3 The Ocean Over Time</i> <i>Pgs.48-67</i></p> <p>Activity: The Ocean and History Lab: Investigating Marine Algae</p> <p>EQ: Should we explore our ocean?</p>	<p>SC.912.N.1.2 SC.912.N.1.6 SC.912.N.1.7 MAFS.912.S.1.2</p>	<p>5-6 periods</p>
<ul style="list-style-type: none"> <li>• Mapping and Navigation</li> <li>• Satellite Tracking</li> <li>• Ocean Technologies</li> </ul> <p><i>Lesson 4 Migrations in the Sea</i> <i>Pgs.68-87</i></p> <p>EQ: How do we explore our oceans?</p>	<p>SC.912.N.1.2 SC.912.N.1.5 SC.912.N.1.6 SC.912.N.1.7 SC.912.N.2.4</p>	<p>3-4 periods</p>
<ul style="list-style-type: none"> <li>• Changing Ocean Conditions with Depth</li> <li>• Deep Ocean Circulation</li> <li>• SCUBA and Submersibles</li> </ul> <p><i>Lesson 11 Voyage to the Deep</i> <i>Pgs.222-243</i></p> <p>Activity: Variations in the Ocean Lab: Investigating Changes in Water Temperature</p> <p>EQ: How is our ocean's water unique?</p>	<p>SC.912.L.17.2 MAFS.912.S.1.2 MAFS.912.S.3.2</p>	<p>4-5 periods</p>

<ul style="list-style-type: none"> <li>• Scientific Process and Inquiry</li> <li>• Data Collection and Analysis</li> <li>• Drawing Conclusions</li> </ul> <p><i>Lesson 21 Student Expert Research</i> <i>Pgs.416-433</i></p> <p>EQ: What do we need to know about our ocean?</p>	<p>SC.912.N.1.1 SC.912.N.1.2 SC.912.N.1.4 SC.912.E.6.5 SC.912.L.17.2 SC.912.L.17.4 LAFS.1112.4.2</p>	<p>15 periods</p>
<ul style="list-style-type: none"> <li>• Critical Thinking Skills</li> <li>• Reviewing Case Studies</li> <li>• Reporting Research Information</li> </ul> <p><i>Lesson 22 Student Expert Analysis</i> <i>Pgs.434-453</i></p> <p>EQ: What information about our ocean should we trust?</p>	<p>SC.912.N.1.1 SC.912.N.1.4 SC.912.N.1.6 SC.912.N.1.7</p>	<p>3 periods</p>
<p><b><u>Ocean Basins and Formation</u></b></p>		
<ul style="list-style-type: none"> <li>• Features of the Ocean Floor</li> <li>• Sonar and Bathymetry</li> <li>• Echolocation and Marine Animals</li> </ul> <p><i>Lesson 5 Explore the Seafloor</i> <i>Pgs.88-111</i></p> <p>Lab: Classroom Model of the Ocean Floor</p> <p>EQ: How well do we know what the ocean floor looks like?</p>	<p>SC.912.N.2.4 SC.912.N.2.5 SC.912.N.3.5 SC.912.E.6.5 SC.912.L.17.2 MAFS.912.S.3.2</p>	<p>5-6 periods</p>
<ul style="list-style-type: none"> <li>• Plate Tectonics</li> <li>• Geologic History of Florida</li> <li>• Crustal Movement Events and Tsunamis</li> </ul> <p><i>Lesson 6 The formation of the Ocean</i> <i>Pgs.112-131</i></p> <p>Activity: Exploring Oceanic Evidence for Plate Tectonics</p> <p>EQ: What is the risk of tectonic events in Florida?</p>	<p>SC.912.E.6.3 SC.912.E.6.5 SC.912.N.1.3 SC.912.N.2.1 SC.912.N.2.4 SC.912.N.3.1 SC.912.N.3.5</p>	<p>5-6 periods</p>

<ul style="list-style-type: none"> <li>• Solar Radiation</li> <li>• Seasonal Changes</li> <li>• Impact of Seasonal Changes on Marine Animals</li> </ul> <p><i>Lesson 7 Seasons of Change</i> <i>Pgs.132-153</i></p> <p>Demonstration: Modeling the Seasons Lab: The Sun’s Rays Demonstration: It’s all about Rays</p> <p>EQ: What determines where marine animals live?</p>	<p>SC.912.L.17.4 SC.912.P.10.20</p>	<p>4-5 periods</p>
<ul style="list-style-type: none"> <li>• Topographic Maps and Water Shed</li> <li>• Water Quality Testing</li> <li>• Florida’s Aquifer</li> </ul> <p><i>Lesson 23 Which Way to the Sea?</i> <i>Pgs.456-477</i></p> <p>Activity: Reading Topographical Maps Lab: Data Collection in the Field</p> <p>EQ: How safe is our water?</p>	<p>SC.912.N1.1 SC.912.L.17.7 SC.912.L.17.11 SC.912.L.18.12</p>	<p>5-6 periods</p>

<ul style="list-style-type: none"> <li>• Runoff and Nutrient Loading</li> <li>• Gulf of Mexico Dead Zone</li> <li>• Indian River Lagoon’s Algae Blooms</li> </ul> <p><i>Lesson 24 Runoff and Phytoplankton</i> <i>Pgs.478-489</i></p> <p>Lab: Light or Nutrients CyberLab: Gulf of Mexico Dead Zone</p> <p>EQ: Do our waterways need help?</p>	<p>SC.912.L.17.8 SC.912.L.17.16 MAFS.912.S.3.2</p>	<p>5 minutes each day for 10 periods</p>
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<ul style="list-style-type: none"> <li>• Global Air Masses and Climate</li> <li>• Weather Patterns</li> <li>• Hurricanes</li> </ul> <p><i>Lesson 10 Weather, Climate, and the Oceans</i> <i>Pgs.196-221</i></p> <p>Activity: Analyzing Weather and Climate Data</p> <p>EQ: Why do hurricanes move toward Florida?</p>	<p>SC.912.E.7.4 SC.912.E.7.6 SC.912.E.17.10 SC.912.L.18.12 MAFS.912.S.1.2 MAFS.912.S.3.2</p>	<p>4-5 periods</p>
<ul style="list-style-type: none"> <li>• Wave Characteristics</li> <li>• Use of Wave Energy</li> <li>• Wave Impact on Shorelines</li> </ul> <p><i>Lesson 18 Waves and the Ocean</i> <i>Pgs.356-377</i></p> <p>Demonstration: Human Wave</p> <p>EQ: Why are some places best known for surfing?</p>	<p>SC.912.L.17.3 SC.912.L.17.11 SC.912.N.4.2 SC.912.P.10.20 MAFS.912.S.3.2</p>	<p>4-5 periods</p>
<ul style="list-style-type: none"> <li>• Causes of Tides</li> <li>• Tidal Variations and Coastlines</li> <li>• Tidal Effects on Marine Animals</li> </ul> <p><i>Lesson 19 A Time for Tides</i> <i>Pgs.378-397</i></p> <p>Activity: Analyzing Tides in Port Canaveral, Florida</p> <p>EQ: What is the difference between waves and tides?</p>	<p>SC.912.L.17.2 SC.912.L.17.3 SC.912.L.17.7 MAFS.912.S.3.2</p>	<p>3-4 periods</p>
<p><b>SEMESTER 1 EXAM</b></p>		

<p><b><u>Marine Biodiversity</u></b></p> <ul style="list-style-type: none"> <li>• Photosynthesis</li> <li>• Carbon Cycle</li> <li>• Harmful Algae Blooms</li> </ul> <p><i>Lesson 12 Photosynthesis in the Ocean</i> <i>Pgs.244-259</i></p> <p>Demonstration: Observing Photosynthesis</p> <p>EQ: How harmful are algae blooms?</p>	<p>SC.912.E.7.1 SC.912.L.14.6 SC.912.L.14.6 SC.912.L.17.2 SC.912.L.17.4 SC.912.L.17.10</p>	<p>3-4 periods</p>
<ul style="list-style-type: none"> <li>• Classification of Marine Life</li> <li>• Microorganisms</li> <li>• Invertebrates and Vertebrates</li> </ul> <p><i>Lesson 13 Biodiversity in the Ocean</i> <i>Pgs.260-285</i></p> <p>CyberLab: Virtual Plankton Exploration Lab: Local Plankton Exploration Activity: Investigating the Animal Kingdom Lab: Investigating the Structure and Function of the Squid</p> <p>EQ: How do we know what kind of life is in the ocean?</p>	<p>SC.912.N.1.5 SC.912.L.17.8 LAFS.1112.2.2.3</p>	<p>7-8 periods</p>
<ul style="list-style-type: none"> <li>• Impact of Population Growth</li> <li>• Endangered Species</li> <li>• Florida Policy and Regulations</li> </ul> <p><i>Lesson 14 Marine Populations</i> <i>Pgs.286-301</i></p> <p>Activity: Florida's Endangered Species</p> <p>EQ: Should we try to save endangered species?</p>	<p>SC.912.N.4.1 SC.912.N.4.2 SC.912.L.14.6 SC.912.L.17.1 SC.912.L.17.11 MAFS.912.S.3.2</p>	<p>4 periods</p>

<ul style="list-style-type: none"> <li>• Natural Selection of Ocean Species</li> <li>• Adaptation in Marine Ecosystems</li> <li>• Impact of Invasive Species</li> </ul> <p><i>Lesson 15 Population Changes</i> <i>Pgs.302-319</i></p> <p>Activity: Modeling Changes Over Time in Sea Stars</p> <p>EQ: How destructive are invasive species in Florida?</p>	<p>SC.912.N.3.1 SC.912.L.15.13 MAFS.912.S.3.2</p>	<p>4 periods</p>
<ul style="list-style-type: none"> <li>• Feeding and Reproductive Strategies</li> <li>• Defensive Behaviors and Mechanisms</li> <li>• Symbiosis in the Ocean</li> </ul> <p><i>Lesson 17 Relationships in the Ocean</i> <i>Pgs.336-355</i></p> <p>Activity: Symbiotic Relationships in the Ocean Activity: Symbiosis Game</p> <p>EQ: How do different species know to help each other?</p>	<p>SC.912.N.1.4 SC.912.L.15.13 SC.912.L.17.6 LAFS.1112.2.2.3 LAFS.1112.4.2.2</p>	<p>4-5 periods</p>
<p><b><u>Marine Ecosystems</u></b></p> <ul style="list-style-type: none"> <li>• Abiotic and Biotic Factors</li> <li>• Diversity of Marine Ecosystems</li> <li>• National Marine Sanctuaries</li> </ul> <p><i>Lesson 1 Diving into Ocean Ecosystems</i> <i>Pgs.2-17</i></p> <p>Activity: Marine Ecosystems</p> <p>EQ: Which marine ecosystems are most valuable?</p>	<p>SC.912.L.17.4 SC.912.L.17.7 LAFS.1112.4.2.2</p>	<p>5-6 periods</p>

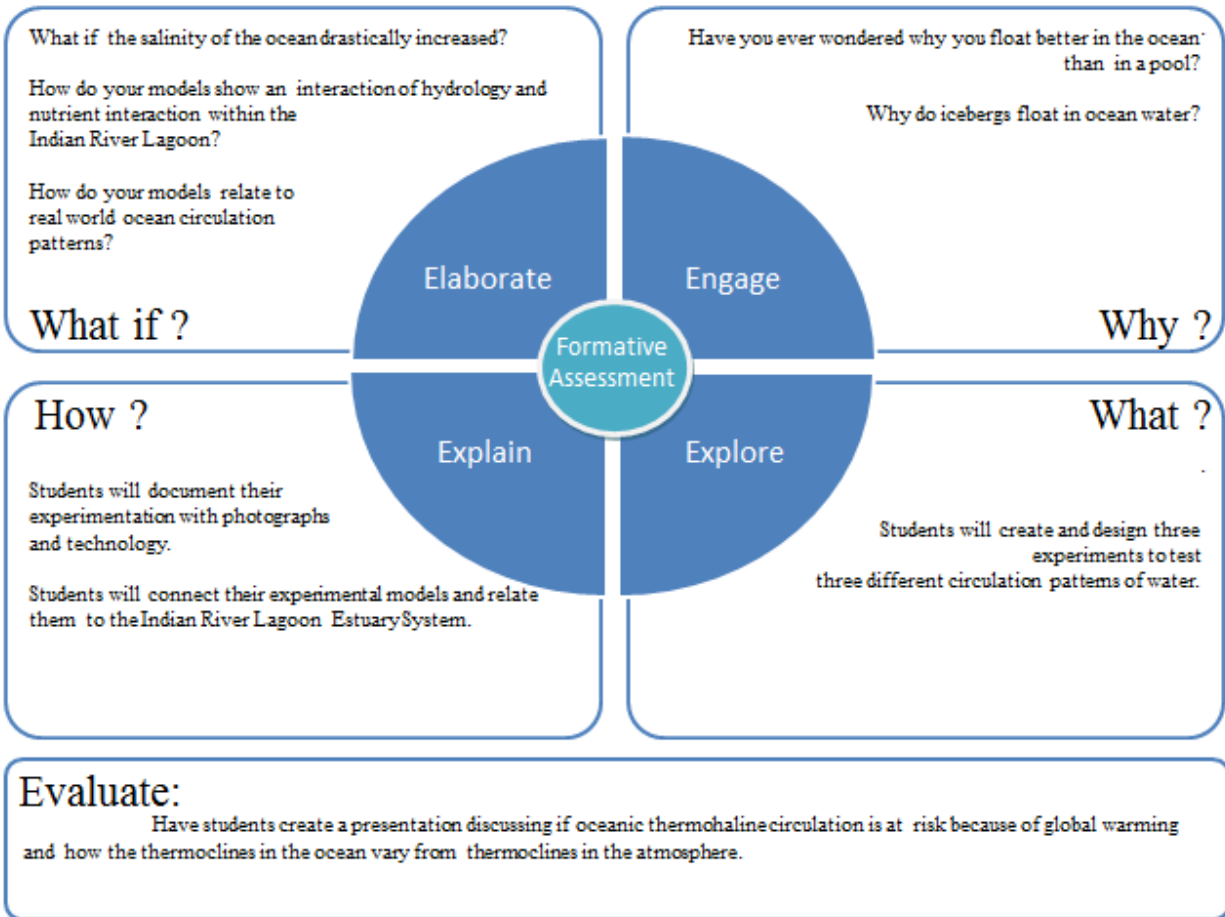


<ul style="list-style-type: none"> <li>• Food Chains and Food Webs</li> <li>• Cycling of Nutrients and Energy</li> <li>• Phytoplankton and Marine Animals</li> </ul> <p><i>Lesson 16 Food Webs in Action</i> <i>Pgs.320-335</i></p> <p>Activity: From Tiny to Tremendous: Marine Food Webs Activity: Building Marine Food Webs</p> <p>EQ: How significant is the decline of one species?</p>	<p>SC.912.N.1.6 SC.912.N.3.5 SC.912.E.7.1 SC.912.L.17.7 SC.912.L.17.9 SC.912.L.17.10</p>	<p>3 periods</p>
<ul style="list-style-type: none"> <li>• Categories of Pollutants</li> <li>• Marine Debris</li> <li>• Oil Spills</li> </ul> <p><i>Lesson 25 Marine Pollution</i> <i>Pgs.490-509</i></p> <p>CyberLab: Marine Pollutants CyberLab: Garbage Patches Lab: Campus Debris Survey Lab: Oil Spill Simulation</p> <p>EQ: What can we do to reduce ocean pollution?</p>	<p>SC.912.N.1.1 SC.912.N.3.5 SC.912.N.4.1 SC.912.N.4.2 SC.912.L.17.8 SC.912.L.17.16 MAFS.912.S.3.2</p>	<p>7-9 periods</p>
<ul style="list-style-type: none"> <li>• Wetlands</li> <li>• Barrier Islands / Indian River Lagoon</li> <li>• Coastal Development</li> </ul> <p><i>Lesson 26 Humans and Coastlines</i> <i>Pgs.510-527</i></p> <p>Lab: Investigating a Model of Wetlands Activity: Hurricane Contour Map</p> <p>EQ: Should we change our coastlines?</p>	<p>SC.912.N.3.5 SC.912.N.4.1 SC.912.N.4.2 SC.912.L.17.4 SC.912.L.17.11</p>	<p>3-4 periods</p>

<ul style="list-style-type: none"> <li>• National and International Waters</li> <li>• Marine Protected Areas</li> <li>• Artificial Reefs</li> </ul> <p><i>Lesson 29 Protecting Marine Habitats</i> <i>Pgs.580-596</i></p> <p>CyberLab: Hawaiian Map CyberLab:Arctic Mammals and Animals of the Antarctic</p> <p>EQ: How effectively can we protect the ocean?</p>	<p>SC.912.N.4.1 SC.912.N.4.2 SC.912.L.17.11</p>	<p>4-5 periods</p>
<p><b><u>Ocean Resources and Society</u></b></p> <ul style="list-style-type: none"> <li>• Upwelling, Nutrients, and Oxygen</li> <li>• Animal Tracking</li> <li>• Sustainable Seafood</li> </ul> <p><i>Lesson 20 Animal Needs and Animal Tracking</i> <i>Pgs.398-413</i></p> <p>CyberLab: Oxygen in the Water</p> <p>EQ: How do ocean systems support animal needs?</p>	<p>SC.912.N.1.2 SC.912.L.17.2 SC.912.L.17.3 SC.912.L.17.7 MAFS.912.S.3.2</p>	<p>3-4 periods</p>
<ul style="list-style-type: none"> <li>• Renewable Resources</li> <li>• Nonrenewable Resources</li> <li>• Management of Ocean Resources</li> </ul> <p><i>Lesson 27 The Ocean's Resources</i> <i>Pgs.528-547</i></p> <p>Activity: Fishing for Resources</p> <p>EQ: How sustainable are the ocean's resources?</p>	<p>SC.912.N.4.1 SC.912.N.4.2 SC.912.L.17.8 SC.912.L.17.11 SC.912.E.7.9</p>	<p>3-4 periods</p>

<ul style="list-style-type: none"> <li>• Causes of Climate Change</li> <li>• Effects of Climate Change</li> <li>• Ocean Acidification</li> </ul> <p><i>Lesson 28 Changing Climate</i> <i>Pgs.548-579</i></p> <p>CyberLab: Climate Changes  CyberLab: Coral Reefs  Activity: Greenhouse Gas Interactive Tool  Lab: Investigating Sea Level Rise  CyberLab: Sea Surface Anomaly  CyberLab: California Sea Lion</p> <p>EQ: Should we do anything about climate change?</p>	<p>SC.912.N.1.3  SC.912.N.1.5  SC.912.N.1.6  SC.912.N.2.5  SC.912.N.3.5  SC.912.L.17.2  SC.912.L.17.4  SC.912.L.17.8  SC.912.L.17.11  SC.912.L.17.16  MAFS.912.S.3.2</p>	<p>7-8  periods</p>
<p><b>SEMESTER 2 EXAM</b></p>		

## 5E Lesson Example for the Engineering Design Practice NGSS



For a 5 E density circulation model lesson and importance to the Indian River Lagoon, go to the following link on the Brevard Google Account:

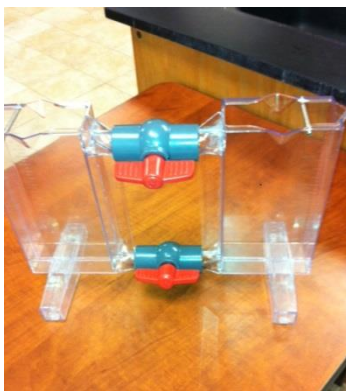
[https://drive.google.com/folderview?id=0BwUIyrlL\\_ojNdkp4TWZMejNiMUK&usp=sharing](https://drive.google.com/folderview?id=0BwUIyrlL_ojNdkp4TWZMejNiMUK&usp=sharing)

# 5 E Inquiry on Density Circulation and the importance to the Indian River lagoon



This activity needs the Density/Circulation apparatus (or equivalent) from PASCO for this activity.

[http://www.pasco.com/prodCatalog/ME/ME-6816\\_density-circulation-model/index.cfm](http://www.pasco.com/prodCatalog/ME/ME-6816_density-circulation-model/index.cfm)



# What do these photos have in common? (Start slide show here)



Slide show engagement and other folders needed for the lesson are on Brevard Google Account at the following link:

[https://drive.google.com/folderview?id=0BwUIyLrL\\_ojNdkp4TWZMejNiMUk&usp=sharing](https://drive.google.com/folderview?id=0BwUIyLrL_ojNdkp4TWZMejNiMUk&usp=sharing)

## Additional Resources

ABC News <a href="http://www.abcnews.com">www.abcnews.com</a>	Bill Nye the Science Guy <a href="http://www.billnye.com">www.billnye.com</a>
Biology Corner <a href="http://www.biologycorner.com">www.biologycorner.com</a>	Brevard Teachers Science Resource Page <a href="http://secondarypgms.brevard.k12.fl.us/scienc/ecurric.htm">http://secondarypgms.brevard.k12.fl.us/scienc/ecurric.htm</a>
Biology Text/Miller and Levine <a href="http://www.biology.com">www.biology.com</a>	Brevard Zoo <a href="http://www.brevardzoo.org">www.brevardzoo.org</a>
CBS News <a href="http://www.cbsnews.com">www.cbsnews.com</a>	Biology EOC Review Site <a href="http://www.ecsd-fl.schoolloop.com/biologyeocreview">http://www.ecsd-fl.schoolloop.com/biologyeocreview</a>
Bozeman Science <a href="http://www.bozemanscience.com/biology-main-page">http://www.bozemanscience.com/biology-main-page</a>	Discovery Channel <a href="http://www.discovery.com">www.discovery.com</a>
Discovery School <a href="http://www.discoveryeducation.com">www.discoveryeducation.com</a>	Environmental Protection Agency <a href="http://www.epa.gov">www.epa.gov</a>
Eisenhower National Clearinghouse <a href="http://www.goenc.com">www.goenc.com</a>	Evolution <a href="http://evolution.berkeley.edu/">http://evolution.berkeley.edu/</a>
The Exploratorium <a href="http://www.exploratorium.edu">www.exploratorium.edu</a>	Zooniverse <a href="https://www.zooniverse.org/">https://www.zooniverse.org/</a>
Extreme Science <a href="http://extremescience.com/">http://extremescience.com/</a>	Florida Dept. of Environmental Protection <a href="http://www.dep.state.fl.us">www.dep.state.fl.us</a>
Fl. Fish & Wildlife Conservation Commission <a href="http://www.myfwc.com">www.myfwc.com</a>	Florida Geological Survey <a href="http://www.dep.state.fl.us/geo/">www.dep.state.fl.us/geo/</a>
Heavens – Above <a href="http://www.heavens-above.com">www.heavens-above.com</a>	Miller and Levine <a href="http://www.millerandlevine.com">www.millerandlevine.com</a>
NASA <a href="http://www.nasa.gov">www.nasa.gov</a>	NASA’s Earth Observatory <a href="http://earthobservatory.nasa.gov/">http://earthobservatory.nasa.gov/</a>
National Association of Biology Teachers <a href="http://www.nabt.org">www.nabt.org</a>	National Geographic <a href="http://www.nationalgeographic.com">www.nationalgeographic.com</a>
National Institute of Drug Abuse <a href="http://www.NIDA.nih.gov/NIDAHome1.html">www.NIDA.nih.gov/NIDAHome1.html</a>	National Science Teachers Association <a href="http://www.nsta.org">www.nsta.org</a>
NBC News <a href="http://www.nbcnews.com">www.nbcnews.com</a>	Newton’s Apple <a href="http://www.tpt.org/newtons/">http://www.tpt.org/newtons/</a>
PBS evolution website <a href="http://www.pbs.org/wgbh/evolution">www.pbs.org/wgbh/evolution</a>	Pearson Training <a href="http://www.mypearsontraining.com/products/biology/2010/tutorials.asp">http://www.mypearsontraining.com/products/biology/2010/tutorials.asp</a> Pearson Web Site Log-in <a href="https://www.pearsonsuccessnet.com/snpapp/login/login.jsp?showLoginPage=true">https://www.pearsonsuccessnet.com/snpapp/login/login.jsp?showLoginPage=true</a>
Science News <a href="http://www.sciencenews.org">www.sciencenews.org</a>	Science Resource Center <a href="http://chem.lapeer.org/">http://chem.lapeer.org/</a>

Scientific American <a href="http://www.scientificamerican.com/">http://www.scientificamerican.com/</a>	Sea Grant Florida <a href="http://www.flseagrant.org">www.flseagrant.org</a>
Sea Turtle Preservation Society <a href="http://www.seaturtlespacecoast.org">www.seaturtlespacecoast.org</a>	Sea World <a href="http://www.seaworld.org">www.seaworld.org</a>
St. Johns River Water Management District <a href="http://sjr.state.fl.us/">http://sjr.state.fl.us/</a>	Understanding Science <a href="http://undsci.berkeley.edu/">http://undsci.berkeley.edu/</a>
Union of Concerned Scientists <a href="http://www.ucsusa.org">www.ucsusa.org</a>	UF: Center for Precollegiate Education and Training <a href="http://www.cpet.ufl.edu/BestPractices/Default.html">www.cpet.ufl.edu/BestPractices/Default.html</a>
U.S. Fish and Wildlife Service <a href="http://www.fws.gov">www.fws.gov</a>	U.S. Geological Survey <a href="http://www.usgs.gov">www.usgs.gov</a>
U.S. National Weather Service <a href="http://weather.gov">http://weather.gov</a>	Water Science for Schools <a href="http://ga.water.usgs.gov/edu">http://ga.water.usgs.gov/edu</a>
The Weather Channel <a href="http://www.weatherchannel.com">www.weatherchannel.com</a>	Woods Hole Oceanographic Institution <a href="http://www.whoi.edu/">http://www.whoi.edu/</a>

### **Brevard Public Schools:**

**Safe Science:** This document has been provided to every school to guide teachers in the use of safe practices for teaching science. Please check with Science Department Chair for 2013 document. A digital version is located under class documents on BSEND.

**Secondary Science Research Guides:** Invaluable information for secondary science research teachers. <http://secondarypgms.brevard.k12.fl.us/bestpractices.htm>

### **Community Resources:**

Archie Carr National Wildlife Refuge, Vero Beach

<http://www.fws.gov/archiecarr/>

Astronaut Hall of Fame, Titusville

<http://www.kennedyspacecenter.com/the-experience/us-astronaut-hall-of-fame.aspx>

Astronaut Memorial Planetarium & Observatory

<http://web21.brevard.cc.fl.us/planet/>

Brevard Agricultural Extension, Cocoa <http://brevard.ifas.ufl.edu/>

Brevard County Parks <http://www.brevardcounty.us/ParksRecreation/Home>

Brevard Museum of History & Natural Science

<http://nbbd.com/godo/BrevardMuseum/index.html>

Brevard Zoo, Melbourne <https://brevardzoo.org/>



Busch Gardens, Tampa

[http://seaworldparks.com/buschgardens-tampa/Book-Online/Tickets/MostPopularTourist?Keyword=busch%20gardens%20tampa&MatchType=e&k\\_clickid=4e9e3b52-5516-eea9-ebf2-00000046e338&keyword=busch%20gardens%20tampa&utm\\_source=bing&utm\\_campaign=Brand%20Core%20Resident&utm\\_term=busch%20gardens%20tampa&utm\\_medium=cpc](http://seaworldparks.com/buschgardens-tampa/Book-Online/Tickets/MostPopularTourist?Keyword=busch%20gardens%20tampa&MatchType=e&k_clickid=4e9e3b52-5516-eea9-ebf2-00000046e338&keyword=busch%20gardens%20tampa&utm_source=bing&utm_campaign=Brand%20Core%20Resident&utm_term=busch%20gardens%20tampa&utm_medium=cpc)

Canaveral National Seashore, Titusville <http://www.nps.gov/cana/index.htm>

Canaveral Port Authority, Cape Canaveral <http://portcanaveral.com/>

Disney World, Orlando <https://disneyworld.disney.go.com/>

Disney's Animal Kingdom <https://disneyworld.disney.go.com/destinations/animal-kingdom/>

The Enchanted Forest Nature Sanctuary, Titusville <http://www.nbbd.com/godo/ef/>

Environmental Learning Center, Vero Beach <http://www.discoverelc.org/>

Epcot, Orlando <https://disneyworld.disney.go.com/destinations/epcot/>

The Florida Aquarium, Tampa <http://www.flaquarium.org/>

Florida Power and Light <http://fpl.com/>

Florida Solar Energy Center, Cocoa <http://www.floridaenergycenter.org/en/>

Florida Today, Melbourne <http://www.floridatoday.com/>

Gatorland, Orlando <http://www.gatorland.com/>

Harbor Branch Oceanographic Institution, Ft. Pierce <http://www.fau.edu/hboi/>

Johnson Controls World Services, Cape Canaveral

[http://www.governmentcontractswon.com/department/defense/johnson\\_controls\\_world\\_service\\_186023479.asp?yr=00](http://www.governmentcontractswon.com/department/defense/johnson_controls_world_service_186023479.asp?yr=00)

Keep Brevard Beautiful, Inc., Cocoa <http://www.keepbrevardbeautiful.org/>

Kennedy Space Center, Visitors Center

[http://www.kennedyspacecentertours.net/?ctt\\_id=1736229&ctt\\_adnw=Google&ctt\\_ch=ps&ctt\\_entity=tc&ctt\\_cli=11x23045x69428x514382&ctt\\_kw=kennedy%20space%20center%20visitors%20center&ctt\\_adid={creative}&ctt\\_nwtype=search](http://www.kennedyspacecentertours.net/?ctt_id=1736229&ctt_adnw=Google&ctt_ch=ps&ctt_entity=tc&ctt_cli=11x23045x69428x514382&ctt_kw=kennedy%20space%20center%20visitors%20center&ctt_adid={creative}&ctt_nwtype=search)

Maxwell C. King Center for the Performing Arts, Box Office <http://www.kingcenter.com/>

Melbourne International Airport, Melbourne <http://www.mlair.com/>

Merritt Island National Wildlife Refuge, Titusville <http://www.fws.gov/merrittisland/>

National Estuary Program - Indian River Lagoon

<http://www.brevardcounty.us/docs/default-source/watshed-presentations-and-reports/advancing-restoration-01-successes-of-the-nep.pdf?sfvrsn=2>

NASA Public Relations <http://science.nasa.gov/about-us/public-affairs-points-of-contact/>

Orlando Science Center, Orlando <http://www.osc.org/>

Pelican Island National Wildlife Refuge, Vero Beach <http://www.fws.gov/pelicanIsland/>

Rockledge Gardens, Rockledge <http://rockledgegardens.com/>

Space Coast Stadium, Viera

[http://www.milb.com/content/page.jsp?sid=t503&ynd=20060118&content\\_id=38468&vkey=team1](http://www.milb.com/content/page.jsp?sid=t503&ynd=20060118&content_id=38468&vkey=team1)

St. John's River Water Management, Palm Bay Service Center

<http://www.sjrwmd.com/contactus/offices.html>

Samson's Island, Satellite Beach (Recreation Dept.)

<http://www.satellitebeachrecreation.org/Pages/SamsonsIsland.aspx>

Sea Turtle Preservation Society, Indian River Lagoon <http://www.seaturtlespacecoast.org/>

Sea World, Orlando <http://seaworldparks.com/en/seaworld-orlando>

Turkey Creek Park, Palm Bay

[http://www.palmbayflorida.org/parks/city\\_parks/turkey\\_creek.html](http://www.palmbayflorida.org/parks/city_parks/turkey_creek.html)

U.S. Astronaut Hall of Fame, KSC <http://www.kennedyspacecenter.com/the-experience/us-astronaut-hall-of-fame.aspx>

Universal Studios, Orlando <https://www.universalorlando.com/>

Valiant Air Command Warbird Museum, Titusville <http://vacwarbirds.org/>

Wonder Works, Orlando <http://www.wonderworksonline.com/orlando/plan-your-visit/ticket-pricing/>

SCHOOL BOARD OF BREVARD COUNTY

Educational Services Facility  
2700 Judge Fran Jamieson Way  
Viera, Florida 32940-6699

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NONDISCRIMINATION NOTICE

It is the policy of the School Board of Brevard County to offer the opportunity to all **students** to participate in appropriate programs and activities without regard to race, color, gender, religion, national origin, disability, marital status, or age, except as otherwise provided by Federal law or by Florida state law.

A **student** having a grievance concerning discrimination may contact:

Dr. Brian Binggeli Superintendent Brevard Public Schools	Ms. Cyndi Van Meter Associate Superintendent Division of Curriculum and Instruction Equity Coordinator	Mr. Robin Novelli, Director Office of High School Programs	Ms. Pam Treadwell, Director ESE Program Support Services ADA/Section 504 Coordinator
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School Board of Brevard County  
2700 Judge Fran Jamieson Way  
Viera, Florida 32940-6699  
(321) 631-1911

It is the policy of the School Board of Brevard County not to discriminate against **employees** or **applicants** for employment on the basis of race, color, religion, sex, national origin, participation and membership in professional or political organizations, marital status, age, or disability. Sexual harassment is a form of employee misconduct which undermines the integrity of the employment relationship, and is prohibited. This policy shall apply to recruitment, employment, transfers, compensation, and other terms and conditions of employment.

An **employee** or **applicant** having a grievance concerning employment may contact:

Ms. Susan Standley, Director Employee Benefits and Special Programs	Mr. Jim Hickey, Director Human Resources Services and Labor Relations
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2700 Judge Fran Jamieson Way  
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