North Carolina Middle Grades Science Strategies Book

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Introduction

The Middle grades Science Instructional Support Documents were written by North Carolina middle grades science teachers for science teachers. The collective ideas are representative of many combined years of successful strategies and lessons. Many of us had our successful practices validated by others that had used the same strategy. We learned from each other and reached the startling conclusion that new buzz words come and go in education, but we seem to circle back around to the tried and true. New names may be attached to strategies and lessons that have been around and in practice for a very long time.

The intent of this document is to present ideas that the Middle Grades Instructional Design Team feels will equip the novice science teacher with ideas to incorporate into lesson planning and to perhaps equip a seasoned teacher with new formatting for an instructional idea. These strategies and lessons should be classified as springboards to begin from, adjust, adapt, change, and improve upon. It is suggested that you explore ways that you can use your “teacher magic” to weave together theses suggested elements, strategies, and ideas in the design of instruction.

As with any strategy or lesson, you are reminded to be flexible with the implementation in your own teaching. In other words, understand that the strategies and lessons are not “carved in stone” and should be adapted to fit the needs of your learners. Even with the overall instructional model, you may find that some “steps” or ideas identified work better in another category. Something we have suggested for an Exploration may work just as well as an Evaluation; an Engagement idea may work better as part of the Elaboration, and so on.

We hope that you find the documents useful. We are so appreciative to teachers from all over our state for their contributions, suggestions, and “trying out” the lessons with their students. A special thanks to Karen Vaughn/Pitt County Teachers and Judy Dean/Craven County Teachers for piloting the lessons.

The Middle Grades Instructional Design Team
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Please understand that we consider these documents to be “works in progress” and plan to continue to improve and refine them. If you have ideas, suggestions, or encounter problems with any websites, please contact Janet Bailey jbailey@dpi.state.nc.us or Clara Stallings cstallin@dpi.state.nc.us.
Instructional Design Model

Middle grades research, science education research, and the collective wisdom of teachers in the field, have yielded the instructional design model adhered to throughout the Strategies Book and the NC Middle grades Science Support Documents. You will recognize components of the learning cycle approach, cooperative learning, and many methods you may be familiar with. These strategies are about how to deliver instruction for the NC Science Standard Course of Study. Much more has to be done to ensure that students learn. The delivery of the curriculum is important, but so is classroom assessment and knowing your students. Many strategies, in the instructional design model explained below, offer ways to differentiate instructional delivery to better match learners in any educational setting. This model is to serve as a flexible guide for planning instruction.

Begin with a “hook” to ENGAGE interest. Remember that middle grade students are “me! me! me!” focused, so you have to plan to focus their attention towards the targeted learning. The engagement should:

- activate/probe prior knowledge,
- establish relevance,
- initiate a need to know more, and
- be of high interest.

Strategies include, but are not limited to:

- brainstorming,
- current events,
- demonstrations,
- discrepant events,
- cartoons,
- stories about scientists,
- unexplained events,
- controversial topics, and
- items selected to spark curiosity about science.
Teacher Notes:
**Instructional Design Model**

Give students opportunities to EXPLORE the learning target. The purpose is to conduct research, design experiments, and to collect data. Many opportunities to EXPLORE may be necessary.

Opportunities to EXPLORE should involve:

- data collection,
- testing predictions,
- exploring explanations,
- a common experience,
- open-ended discussions,
- having multiple solutions, and
- discourse.

Strategies include, but are not limited, to:

- collaborative team work,
- research,
- problem solving, and
- web quests.
**Instructional Design Model**

Next comes the somewhat challenging phase—that of BUILDING UNDERSTANDING/EXPLANATION. Some instructional design models also refer to this stage as INVENTION OF THE CONCEPT. Whatever title is attached to this phase of the instructional design, it is very crucial and critical in order for learning to take place.

During the BUILDING UNDERSTANDING/EXPLANATION phase:

- concept development is the goal,
- misconceptions are readdressed, and
- explanations are based on data-driven evidence.

Strategies include, but are not limited, to:

- questioning,
- providing justifications,
- presentation of findings,
- proposing evidence-driven solutions,
- critiquing of data, and
- having discourse about variance in data and solutions.
Teacher Notes:
Instructional Design Model

Learning is evidenced when transferred to a new situation. This phase, often referred to as ELABORATION, affords the challenge of making the learning meaningful and relevant to the learners. This phase ensures that students construct meaning within a new setting using what they already know.

In the ELABORATION phase of instructional delivery, students get to:

- apply information to new situations or problems,
- make generalizations, and
- defend prior data/findings based on the new situation/problem/experience.

Strategies include, but are not limited, to:

- questioning,
- designing experiments,
- applying science in technological designs, and
- engaging in discourse.
**Instructional Design Model**

The lesson should evolve around the use of skills and content in order to provide evidence of learning. Students should understand clearly how they will be assessed. Ideally, students should help define the criteria for success. Students should be given choices of ways to produce evidence that they have learned. A variety of assessment opportunities improves the chances that students with different preferred learning styles will be provided the opportunity to be successful in science.

The purpose of the EVALUATION phase of the instructional design is to:

- produce evidence of learning,
- demonstrate abilities to use the knowledge in problem solving situations, and
- be guided by clear guidelines and expectations, i.e., a provided rubric.

Strategies include, but are not limited, to:

- compiling portfolios that provide evidence and documentation of the learning journey,
- culminating experiences, and
- student-teacher negotiated projects.
Focus on presenting and explaining ideas

Focus on attaining specific science process skills

Content

Process

Content with Process

Process with Content

Focus on constructing knowledge through active learning

Focus on developing the ability and disposition to investigate

ASPECTS OF INQUIRY-BASED INSTRUCTION
Teacher Notes:
**Portfolio Assessment of the Learning Journey towards Scientific Literacy**

The goal of science education is to promote scientific literacy. Use the dimensions of scientific literacy as the criteria for development of a student portfolio system wherein students are in charge of their portfolios. They are held responsible for documenting their own learning and for providing evidence in the portfolio that they have attained mastery and/or understanding. Long term projects, readings, research papers, writings, review of news articles, etc. may serve as products for the portfolio. The learner compiles evidence which shows “I’ve got it”! These understandings should be developed and evidenced in conjunction with content. Portfolios are valuable for student-teacher-parent conferences.

<table>
<thead>
<tr>
<th>The History and Nature of Science</th>
<th>Evidence of Understanding</th>
<th>Justification form completed and attached to evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCIENCE IS…..</strong> public information.</td>
<td>i.e.-Portfolio page 12- Article from the News and Observer critiqued using the ARTICLE Strategy Sheet</td>
<td>√</td>
</tr>
</tbody>
</table>

**Justification Form**

<table>
<thead>
<tr>
<th>Name</th>
<th>Date attached to artifact</th>
</tr>
</thead>
</table>

Dates & Total estimated time spent on this product

Why was this artifact selected as evidence of mastery/understanding of the targeted learning?

What did you learn by doing this product?
Teacher Notes:
# Portfolio Assessment of the Learning Journey towards Scientific Literacy

<table>
<thead>
<tr>
<th>The History and Nature of Science</th>
<th>Evidence of Understanding</th>
<th>Justification form completed and attached to evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCIENCE IS.....</strong> public information.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SCIENCE IS.....</strong> historic.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SCIENCE IS.....</strong> replicable.</td>
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<td></td>
</tr>
<tr>
<td><strong>SCIENCE IS.....</strong> tentative</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SCIENCE IS.....</strong> probabilistic</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SCIENCE IS.....</strong> human/culture related.</td>
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</tbody>
</table>
## Portfolio Assessment of the Learning Journey towards Scientific Literacy

<table>
<thead>
<tr>
<th>Unifying Concepts</th>
<th>Evidence of Understanding</th>
<th>Justification form completed and attached to evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td></td>
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<tr>
<td>Systems</td>
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<tr>
<td>Equilibrium</td>
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<tr>
<td>Evidence</td>
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<tr>
<td>Probability</td>
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<tr>
<td>Modeling</td>
<td></td>
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<tr>
<td>Constancy</td>
<td></td>
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<tr>
<td>Theory</td>
<td></td>
<td></td>
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<tr>
<td>Form and Function</td>
<td></td>
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<tr>
<td>Evolution</td>
<td></td>
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</tbody>
</table>
# Portfolio Assessment of the Learning Journey towards Scientific Literacy

<table>
<thead>
<tr>
<th>Processes and Skills</th>
<th>Evidence of Understanding</th>
<th>Justification form completed and attached to evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td></td>
<td></td>
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<tr>
<td>Communication</td>
<td></td>
<td></td>
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<tr>
<td>Observing/ describing</td>
<td></td>
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<tr>
<td>Working collaboratively</td>
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<tr>
<td>Measuring-labeling of units</td>
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<tr>
<td>Questioning</td>
<td></td>
<td></td>
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<tr>
<td>Using mathematics to analyze and communicate findings</td>
<td></td>
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<tr>
<td>Hypothesizing</td>
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</tbody>
</table>
Teacher Notes:
## Portfolio Assessment of the Learning Journey towards Scientific Literacy

<table>
<thead>
<tr>
<th>Processes and Skills</th>
<th>Evidence of Understanding</th>
<th>Justification form completed and attached to evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicting</td>
<td></td>
<td></td>
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<tr>
<td>Making inferences</td>
<td></td>
<td></td>
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<tr>
<td>Designing experiments</td>
<td></td>
<td></td>
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<tr>
<td>Controlling variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data interpretation</td>
<td></td>
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<tr>
<td>Modeling</td>
<td></td>
<td></td>
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<tr>
<td>Analyzing</td>
<td></td>
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<tr>
<td>Communicating findings</td>
<td></td>
<td></td>
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<tr>
<td>Writing Lab Reports</td>
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</tr>
</tbody>
</table>
## Portfolio Assessment of the Learning Journey towards Scientific Literacy

<table>
<thead>
<tr>
<th>Science/Technology Society/Environment Factors</th>
<th>Evidence of Understanding</th>
<th>Justification form completed and attached to evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science and technology as reciprocals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science and technology is a human enterprise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact of science and technology on society</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact of science and technology on the environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differing perspectives and viewpoints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limits of science and technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethical Issues</td>
<td></td>
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<tr>
<td>Technological Design</td>
<td></td>
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</tr>
</tbody>
</table>
# Portfolio Assessment of the Learning Journey towards Scientific Literacy

<table>
<thead>
<tr>
<th>Scientific and Technical Skills</th>
<th>Evidence of Mastery</th>
<th>Justification form completed and attached to evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Safety</td>
<td></td>
<td></td>
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<tr>
<td>MSDS information applied</td>
<td></td>
<td></td>
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<tr>
<td>Using Equipment Correctly</td>
<td></td>
<td></td>
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<tr>
<td>Appropriate lab techniques</td>
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</tbody>
</table>
## Portfolio Assessment of the Learning Journey towards Scientific Literacy

<table>
<thead>
<tr>
<th>Scientific and Technical Skills</th>
<th>Evidence of Mastery</th>
<th>Justification form completed and attached to evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Based Labs</td>
<td></td>
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<tr>
<td>GPS</td>
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<tr>
<td>GIS</td>
<td></td>
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<tr>
<td>Web Quests</td>
<td></td>
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<tr>
<td>Spread Sheets</td>
<td></td>
<td></td>
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<tr>
<td>Databases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring mass, time, volume, temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative Data</td>
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<td></td>
</tr>
<tr>
<td>Quantitative Data</td>
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</tr>
</tbody>
</table>
Teacher Notes:
**Assessment for Reading Science Information**

Use these descriptors to assess literacy skills utilized in science.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Evidence of Mastery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noting details</td>
<td></td>
</tr>
<tr>
<td>Compare and contrast</td>
<td></td>
</tr>
<tr>
<td>Predicting</td>
<td></td>
</tr>
<tr>
<td>Sequencing events</td>
<td></td>
</tr>
<tr>
<td>Cause and effect</td>
<td></td>
</tr>
<tr>
<td>Distinguish fact from opinions</td>
<td></td>
</tr>
<tr>
<td>Connecting words with precise meaning</td>
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<tr>
<td>Drawing inferences from data</td>
<td></td>
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<tr>
<td>Formulating conclusions</td>
<td></td>
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<tr>
<td>Others:</td>
<td></td>
</tr>
</tbody>
</table>
# Writing In Science

## Editing Sheet

<table>
<thead>
<tr>
<th>Read for Content:</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; draft</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; draft</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have I stated a main idea?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is my introductory paragraph developed?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Have I developed at least 3 supporting paragraphs?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have I supported my 3 paragraph ideas with facts, data, and examples from my experiments, readings, observations, and personal experiences?</td>
<td></td>
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</tr>
<tr>
<td>Have I sequenced my details in a logical order?</td>
<td></td>
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<td></td>
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<tr>
<td>Do I have a conclusion paragraph?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have I used a variety of simple and complex sentence structures?</td>
<td></td>
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</tbody>
</table>

## Read for Mechanics:

- Punctuation
- Capitalization
- End marks
- Spelling

## Read for Grammar:

- Make sure there are no pronoun shifts.
- Subject/verb agreements
- Complete sentences
- Correct verb tense
- Avoid run-on sentences.

Before you rewrite your 2<sup>nd</sup> draft, read your paper out loud.
With a highlighter, mark the ideas you like.
Mark through anything that you do not like.
Test Item Writing Shells for Classroom Assessment

The following “shells” can be used to develop science test items that assess the various levels of thinking skills:

- What is the meaning of ___?
- Which is the best example of ___?
- What is the cause of ___?
- Which most likely will cause ___?
- How does ___ cause ___?
- How does ___ affect ___?
- What effect does ___ have on ___?
- How does ___ affect ___?
- What most likely will happen if ___?
- Which statement best describes ___?
- Which word/term best describes ___?
- Which is the best reason ___?
- Which characteristic does ___ and ___ have in common?
- In what way(s) is/are ___ and ___ similar?
- In what way(s) is/are ___ and ___ different?
- How does ___ compare with ___?
- What is the best way to ___?
- What process is most responsible for ___?
- Which has the greatest effect on ___?
- Which will cause an increase in ___?
- Which will cause a decrease in ___?
- What is the relationship between ___ and ___?
- Which best shows the relationship between ___ and ___?

(Source: Dr. Michael Jones, NCSU-TOPS, Technical Outreach for Public Schools)
Collaborative Inquiry for Science

Science inquiry provides a rich environment for students to construct deep and robust understandings of science concepts, skills, and processes. Inquiry requires the active engagement of students in a variety of activities such as:

- asking questions,
- predicting
- hypothesizing,
- observing,
- reading to find information,
- using tools to gather data,
- seeking various types of evidence,
- using mathematics to analyze data,
- interpreting data,
- synthesizing findings,
- communicating results, and
- asking more questions.

Because science inquiry is interdisciplinary in nature, it is an ideal organizer for middle grades instructional design. Inquiry requires the extensive use of mathematics-in analyzing and communicating quantitative data and language arts-in listening, viewing, discussing, reading comprehension, writing and presentation of findings. One major advantage of the inquiry-based science classroom is that students are expected to use knowledge and skills from other content areas. Inquiry-based science classroom breaks down artificial subject area divisions. Science inquiry provides relevance to math skills and a reason to read and listen. Both oral and written communication are necessary to share results, conclusions, and engage in scientific discourse. Links to social studies abound with science, technology, and societal issues being studied. A strong inquiry-based science program has the potential to build student achievement in many curricular areas, not just science.
Collaborative Inquiry for Science

“Hands on” science is not always inquiry science. There is nothing magic about manipulating materials. The key to science inquiry is the critical and logical thinking that students must employ in order to explore and investigate problems. Inquiry begins and ends with questions. The more students have to think for themselves and make decisions about questions to investigate, the closer they are to engaging in inquiry. Most middle grades students will need some structure and guidance in moving beyond “Hands On” to “Minds On, Hands On Science”, which is another description of inquiry.

In inquiry, the emphasis is not on improving the teacher’s ability to explain important concepts. Something other than “great lectures and explanations” is needed, if middle grades students are to gain understandings which result in long term retention and application of concepts in new situations. Inquiry-based learning environments provide opportunities for exploring, experimenting, questioning, refining, and sharing. This can happen for both the teacher and the student.

Middle grades students learn best when engaged in carefully designed activities that provide an opportunity to “do” something with new information. Inquiry instruction requires students to think about and do something with content. Concepts are “constructed” through time, as students participate in pair and small group explorations, to answer questions about the world around them.

Scientific inquiry requires interaction, sharing of ideas, solutions, and questions that may have more than one answer or no answer at all. With inquiry, it is not the answer that is important. It is the knowledge and skills gained in the pursuit of an answer that will stay with a student and serve him/her well, long past the time the memorized facts and right answers have been forgotten. Albert Einstein must have had scientific inquiry in mind when he defined education as: “that which stays with you after you have forgotten everything you learned in school”. Attainment of the skills associated with inquiry is valuable to all curricular areas and to life in the 21st century.
Teacher Notes:
Moving Toward Inquiry

- Administrators must understand that an inquiry-based classroom/laboratory looks different, sounds different, and requires different equipment/materials than that found in a traditional setting. Some administrators may need to see the value of inquiry learning, as documented in research, before they are willing to step up and support collaborative scientific inquiry.

- Parents must be prepared in advance for inquiry learning. Parents will likely need a full explanation of inquiry-based instruction and how to support its tenets. Research that identifies the benefits and appropriateness of inquiry-based learning environments will need to be shared. Creating a “parent’s corner” in the classroom that has information about this style of instruction is welcoming to parents. Convey to parents that many different resources will be used.

- Some students are not accustomed to having to figure things out on their own. In fact, some students like the idea of teachers supplying answers. This certainly saves students the trouble of truly engaging their brains. A quick look at current research on the brain and how students learn boils down to: “no brain engagement, no learning”. So, students must understand that inquiry is embraced in the classroom, so that they can learn.

- Make the transition to open inquiry slowly. If students are accustomed to performing “cook book style” lab activities, a few small changes at a time, can move investigations to guided inquiry. Strategies such as having students decide what kind of data to collect, how to measure it, what kind of data table is needed, and what kind of graph is most appropriate for the data are starting points. Having students share the variety and significance of their data, with the class, provides the opportunity to compare and contrast results that can lead to very lively and interesting dialog and perhaps more questions to pursue.

- The transition from replicable labs to guided inquiry requires that students take on the responsibility of experimental design. The teacher provides materials and equipment for the exploration of an agreed upon question. Student groups will design different procedures, will get different results, and will interpret those results in unique ways. The resulting discussion and evaluation of each group’s efforts has the potential for a very lively, interesting, and engaging lesson – just the kind of discussion that builds deep and robust understanding of curriculum content.

- Replicable labs have a purpose in science since replication of results is a part of the nature of science. Labs with known ranges of data and known results are comfortable for student and teacher alike.

- The instructional development to guided inquiry and then to open inquiry is a journey. Many explorations for concept development may be needed and can take on the various forms of inquiry.
Teacher Notes:
Managing Materials for Inquiry-based Instruction

Organizing Materials

- Have standard operating procedures for storage, distribution, and collection of materials that are effective for distribution of materials and clean up.
- Establish jobs and procedures early in the school year. Once students learn procedures, class time can be utilized more efficiently. Use resealable plastic bags, shoe boxes, plastic containers, tubs, or bins for labeling and storing materials.
- Devise and train students in methods of distributing and collecting activity materials. For example, one student’s role/job/responsibility is to pick up and return materials. Everyone else remains seated or at the lab station.
- When all groups will use the same materials, package materials in resealable plastic bags for quick distribution to groups. Tape a card with a list of materials to the inside of the bag. First period students can collect materials. At end of first period, students check the list to be sure that all materials have been returned to bag and are ready for the next class. The list is checked at beginning of next class and any damaged or missing materials reported.
- If possible, store associated materials, such as black line masters and laminated class sets of information sheets, in the same container.
- Plastic containers can serve as “caddies” for often used materials, such as scissors, glue, tape, and rulers. Each container is assigned a group number. The corresponding numbered group is responsible for returning the caddie.
- If trash will be generated in some way, prevent multiple trips to the class trash can by taping plastic grocery bags to each group’s table/desk.
- Setting up materials on disposable, plastic trays is good for “messy” activities. Cleanup is easier, as the activity can be done on the tray and then disposed of.

Dealing with Limited Materials

- When possible and appropriate, find substitutes for expensive laboratory equipment, i.e., cups in place of beakers.
- Be prepared with list of materials that you need for inquiry activities. When administrators, parents, parent groups, civic groups, or businesses ask, “What I can do to help?”—share the list. If they don’t ask you, then you can ask them for help.
- Organize rotation labs in which groups rotate through lab stations.
- Set up learning centers or stations that groups may rotate through.
- Write grants.
Teacher Notes:
Managing Student Behavior during Inquiry-based Instruction

- Set clear standards and expectations for appropriate behavior, movement, and voices.
- Avoid assuming that students know how to conduct themselves during inquiry investigations.
- Learning to display respect is valuable to success in life, as well as in the science laboratory. Demonstration of displaying respect for materials and peers and adherence to standards and expectations for appropriate behavior should be a prerequisite for participation in laboratory activities. Modeling, reviewing, coaching for, and calling attention to what “respect” looks like, is time well spent.
- Students must know that they are “in charge” of their own learning. If they are not engaged in the learning experience because of inappropriate behavior, academics will suffer.
- Establishing learning teams that engage all team members and bring out the best in each student, takes thought, planning, and persistence, but is well worth the effort.
- Decide on appropriate group size for inquiry investigations. Groups of no more than 4 students usually work best.
- Place students in groups to create diversity. Leave groups in tact long enough to establish group identity.
- Work on team building with collaborative learning groups. Refer to the groups as “learning teams”. Teams need to sit and work together on many kind of activities, so that they become comfortable working together on lab activities. Selecting a name or engaging in games with other teams can build team identity and unity.
- Offer simple rewards to teams sparingly. Getting to leave first at the end of class, as all other groups remain seated, is a simple but much sought after reward.
- Remember, standards and expectations are set for the laboratory. Approach compliance with expectations and standards as a non-negotiable.
Managing Student Behavior during Inquiry-based Instruction

- Use simple, high interest activities to give students practice in scientific thinking and processes. At first, develop investigations as a class. The teacher models and coaches for skills necessary for inquiry and appropriate behavior.

- Establish a “Freeze, Listen to me” signal to use, when you need students to stop whatever they are engaged in to focus on the teacher. This refocusing signal can be a clap of the hands, a chime, teacher holds up his/her hand until all students hold up their hands and all attention is on the teacher, or make a zero with your hands for “Zero Noise”.

- Model and practice using quiet “cooperative voices”. Voices needed for work in pairs and teams are not the same as those needed during whole class discussions. A member of each team might be assigned the role of “voice monitor”. Most teachers may want to also establish a non-verbal signal that alerts students to turn the volume down, which is different from the zero-noise, focus your attention on the teacher signal.

- Establish simple “Hands OFF/ Hands ON Rules” for all materials, i.e., “Hands off” until instructions are given; “Hands ON” only for intended use.

- Teachers should exercise the right to say, “No. That is not correct…”, especially when dealing with improper behaviors and non-compliance with safety standards.

- Establish a time out plan for a student who needs isolation from the group due to non-compliance with standard operating procedures and/or expectations for behavior.

- Mark off a safety zone away from the lab area, where students can stand to take off goggles when a lab is in session. Rules for use will need to be established, i.e., “Only one occupant in the safety zone at a time”.
Science Safety

Personal safety is an issue wherever we are and whatever we may be doing. Driving a vehicle, swimming, and playing in a basketball game are examples of situations where certain rules and precautions must be adhered to for personal safety, the well being of others, and in order for the event or team to work effectively. The same is true of the science laboratory. Learning about potential hazards and how to keep one’s self and others safe is a valuable lesson, not only for science class, but for life!

Tips for success in focusing on personal safety

- Set the standard that everyone is responsible for safety—their own and the safety of others.
- Establish clear consequences for non-compliance with safety standards aligned with local policy.
- Administrative support for consequences for non-compliance with safety standards is imperative.
- Involve students in setting safety guidelines for lab activities.
- Empower each student to feel as if he/she is a “safety patrol officer” of the lab.
- Make “Safety First” the motto for all lab investigations throughout the year.
- Stay current with recommended procedures and chemicals for the middle grades science classroom. Many older texts and lab manuals may suggest use of chemicals or activities no longer considered appropriate or safe.
- Do not assume that just because something is in print or in electronic media that it is up-to-date with safety standards.

Strategies

- Ask for a copy of the LEA and your school’s Chemical Hygiene Plan. This plan will provide detailed information about the standard operating procedures related to chemical hygiene.
- Provide a list of laboratory safety rules for each student to keep in their science notebook.
- Ask students to study the list and select ones that they feel are for the year. Have students share ideas and identify those rules that they deem non-negotiable. Students should be prepared to justify their choices. Repeat this for labs and units of study.
- Have each student prepare a diagram of the science lab with location of safety equipment labeled.
- Have students illustrate safety rules. Post signage.
- Explain WHY safety standards/laws/codes exist, i.e., wearing goggles to protect eyes.
- Set the expectation that safety will be addressed completely for all laboratory experiences.
- Provide a safety contract to be signed by student and parent.
- Discuss safety at Open House. Emphasize the importance of safety for all.
- Print safety rules/contract on bright paper.
- Require science safety to be a part of the portfolio assessment.
- Create a web page that addresses science safety. This allows for quick updates when laws, codes, and standards change.
**Safety Reflections and Contract**

I, ________________________________, understand that the science laboratory is a safe place to learn. I must conduct myself in a responsible manner at all times. I have a list of safety rules for the science lab. I have studied possible risks and hazards, had safe procedures explained to me, and I accept my personal role in the safety for my self and my peers.

I consider these 5 rules to be the most important ones for our laboratory.

1. 

2. 

3. 

4. 

5. 

________________________________________________________________________
Student Signature		Date

I have studied the list of safety rules for the science lab and am prepared to follow those rules and guidelines during all lab activities. **I understand the consequences on non-compliance with procedures and expectations.**

I, as a parent and/or guardian of __________________, have read and discussed the safety rules developed for lab activities. I support efforts to maintain a safe learning environment and expect _____________ to adhere to rules and instructions. **I understand the consequences for non-compliance with procedures and expectations.**

________________________________________________________________________
Parent/ Guardian Signature		Date
Experimental Design: Lab Reports

Tips for developing student expertise in writing lab reports

- Provide a copy of the Science Lab Report Outline for each student. Discuss standards and expectations.

- Create a template for word processing the final lab report.

- Model and teach one section at a time if students have had little experience in writing lab reports. Focus on specific sections for an extended period of time. For example, in the first grading period, perfect writing conclusions based on group and class generated data.

- Have students practice writing lab reports first in pairs and then individually.

- Peer critiques can be a valuable learning tool for writing. Establish a color coding system to write both “kudos” and constructive suggestions for peers.

- Allow time for students to practice writing clear, detailed, and replicable procedures, i.e., lab report is due 2 days after the lab has been conducted. Do not accept reports on the day of lab. Simply tell students that they need more time to write robust descriptions.

- Establish an imaginary “absent student” as the audience for the lab report. Specific detail must be included, in order to allow this “absent student”, to repeat the experiment.

- If students are absent on the day of a lab, and it is not possible to make up the lab, review of another student’s lab report could substitute for the lab. Establish a “data spot”-notebook, computer file, etc. for storage of data. The data can be retrieved for absent students and/or for making comparisons with future data collection.

- Conducting very simple investigations represents a good way to introduce students to science processes used in inquiry investigations. Differentiate by having students investigate different variables.

- Data is reported based on group findings. Conclusions, reflections, and new questions should be completed individually.
Teacher Notes:
Experimental Design: Lab Reports

Tips for developing student expertise in writing lab reports

- Sometimes a textbook or lab manual activity is appropriate for a particular learning goal. In this case, have students use the Science Lab Report Outline for their written record of the investigation.

- Consider using textbook or lab manual activity as a starting point. Have students generate other information needed for the Science Lab Report Outline.

- Over time develop student skills related to:
  - posing original questions,
  - identifying variables,
  - using operational definitions for variables,
  - writing procedures for investigations,
  - creating data charts and graphs,
  - analyzing results of data and research, and
  - formulating a conclusion based on data and research.

- Provide all students an opportunity to gain deeper understanding of science concepts and processes by planning for student opportunities to present and defend original research questions, procedures, data analyses and conclusions, before peers.

- The following outline is writing and thinking intensive. Use as appropriate. **DON'T require for all labs.** Sometimes, simply compiling, analyzing, and discussing class results for the lab investigation can allow the desired learning to take place.
Experimental Design: Lab Reports

Problem or Purpose
This is the question you want to investigate.
This question will include the independent and dependent variable of your investigation. It may take the form of:
“What is the effect of ____________ (independent variable) on ____________ (dependent variable)?”

Hypothesis
This is your testable prediction of what you think will happen.
Word your hypothesis as an if/then statement. It should include the independent and dependent variables.
It may take the form of “If the ____________ (independent variable), then the ____________ (dependent variable) will... because”.

Materials
This is a complete list of all the things you need for your investigation similar to ingredients for a recipe. It is important that it be accurate, complete, and very specific. Avoid just listing “beaker”; instead specify a 200 ml beaker. A complete, specific list of materials is needed to ensure that your investigation can be replicated by others.

Variables
These are the things about your experiment that may change. They must be identified and defined operationally before you write any other part of your investigation.

Independent (sometimes called experimental or manipulated variable)
This is the variable that you will intentionally change or manipulate in order to observe the effect of that change on the dependent variable. The “I” in independent serves as a reminder that “I am in charge of this variable and may decide how I want it to change in my investigation” and that “I set the values of the independent variable before I begin my investigation”.

Dependent (sometimes called the responding variable)
This is the variable that is observed, counted or measured as the investigation is done. The “D” is a reminder that this variable depends on what happens as the investigation is done.

Controlled variables (sometimes called constants)
These represent values and conditions that are carefully kept the same through all trials of the investigation to assure a “fair” and valid result. As a rule the more controls you can list, the better your results.
Experimental Design: Lab Reports

Design of Experiment
This section should describe the control or comparison which received no change in conditions for the lab. The sample size should also be discussed.

Safety
Reread your list of Safety Rules and select the ones that are applicable to your investigation. List at least three. Also, write safety rules for procedures and materials, which are specific to the investigation. If chemicals are used, verify that you have read the MSDS for the chemical. Note the Flammability, Health Risks, Reactivity, any special things to consider about this chemical, the appropriate PPE (personal protective equipment) required, and appropriate handling and disposal for chemicals.

Procedure-Steps and Equipment Set-up
These are the steps that someone else would need to follow to replicate your investigation. List and number the steps. Be sure to include how many trials will be conducted for each value of the independent variable. Great care is needed here to ensure that instructions are clear and sequential. Include a drawing of the set up for any equipment.

Data
This is the information you observe, record, and analyze. This section describes information and values related to the dependent variable.

  Qualitative-Write statements of observations using your senses. Explain in complete sentences what you saw, smelled, heard, and/or felt during the investigation. Use labeled drawings to illustrate these observations. Use color and/or symbols, as needed.
  Quantitative-These are the values you measured or counted as observations of the dependent variable. They are most easily recorded in a data chart designed before the investigation begins.
  Data Chart-The data chart should include space for all trials and a place to record the average of all trials for each value of the independent variable. Be sure to include the unit of measure for all data. The data chart should have a title and all columns should be labeled.
  Graph-Use math skills to determine what type of graph best fits the data. Use your graph to determine the relationship of the independent and dependent variables. Be sure your graph has a title. Graph the independent variable on the x-axis and the dependent variable on the y-axis in order. This reflects how a change in the independent variable results in a change in the dependent variable. Be sure to accurately label the x and y axis. Include the unit of measure used for the data. Be sure to include keys and legends for color and/or symbols used to represent data.
Experimental Design: Lab Reports

Analysis/Conclusion
Restate the problem and hypothesis. State whether the data from the investigation supports or rejects the hypothesis. Review and discuss the data. Explain why the data as recorded and graphed supports or rejects your hypothesis. This will require a paragraph of at least five good sentences.

Reflections
This is an opportunity to think carefully about the investigation procedure and results. Use the following questions to guide your writing:

- Were your results as expected? Why or why not?
- What were the sources of error in your investigation? Were there ways that these might have been controlled or reduced?
- Are you confident that the results are reliable and accurate? Why or why not?
- If you were to do the experiment again, what would you change in order to make it more reliable or interesting?
- What is the most important thing you learned as a result of doing this investigation?

Other Questions to Investigate
After having conducted, analyzed, and reflected on this investigation, what new questions do you have? Write at least one testable question that could lead to another investigation.
Experimental Design: Checklist/Standards for Lab Reports

Problem
- Is in form of a testable question
- Includes independent variable
- Includes dependent variable

Hypothesis
- Written in “if”, then” or “if, then, because” format
- Includes independent variable
- Includes dependent variable

Variables
- Independent tells what is tested
- Dependent tells what is measured
- Operational definitions used
- Control/comparison identified

Materials
- List is complete
- List is specific
- Quantity and sizes given

Safety
- Minimum of three rule
- MSDS referenced
- Disposal method
- PPE required
- Specifics for lab

Procedure
- Written as numbered list
- Calls for multiple trials
- Clear, concise, complete
- Replicable

Data
- Qualitative data includes
  - Carefully labeled drawings
  - Descriptive comments
- Quantitative data includes
  - Data table includes all trials and average
  - Appropriate graph with all needed labels
- Symbols and color keys included

Analysis/Conclusion
- Summarizes problem and hypothesis
- States whether data supports hypothesis
- Uses averages of trials to defend support or rejection of hypothesis
- Paragraph of at least five sentences

Reflection
- Paragraph of at least six sentences
- Thoughtful and specific ideas

New Questions
- Testable
- Thoughtful
- Related to investigation

Format
- Neatness
- Parts of report are underlined
- Line skipped between report parts
- Accurate spelling
- Meaningful sentences
- Used template to word process final report
Teacher Notes:
Cooperative Learning/Collaborative Inquiry

Collaboration is a key concept for success in the twenty-first century, whether in business, government, international affairs, or the middle grades science classroom. Research indicates that learning is not acquired by teachers “telling” students everything they need to know about a topic or by assigning reading that covers all key objectives. Successful middle grades science students have teachers who plan a variety of rich experiences from which students may construct personal meaning and understanding of important curriculum content.

Marzano (2001) lists cooperative learning as one of the key strategies for effective instruction that increases student achievement. Learning is a social experience before it is a cognitive one. Structured and focused social interaction is an important aspect of a middle grades science classroom.

Cooperative learning is not the same as “group work”. True cooperative learning promotes teamwork among students in heterogeneous groups. Teams work together on problems, activities, or experiments. They assist and support one another to achieve a common goal. The teacher’s role becomes one of a coach with students being empowered to fulfill their individual responsibilities to the group. Mutual respect and true sense of teamwork can spring forth from the most unlikely adolescents with the implementation of cooperative learning.

Johnson, Johnson, and Holubec (1991) identified five basic elements that must be in place for true cooperative learning to occur:

- Positive Interdependence — the idea that the team “sinks or swims” together,
- Face to Face Interaction — arrangement of the setting so that collaboration is physically possible and materials are shared,
- Individual Accountability — individuals are assessed on the work of cooperative team,
- Interpersonal Skills — skills to function as a group are considered content, and
- Group Processing — taking time to dialog with students on how they function as a group.
Teacher Notes:
Cooperative Learning/Collaborative Inquiry

**Tips for successful implementation of cooperative learning/collaborative inquiry**

- Carefully outline expectations and teach the skills needed for collaborative team learning. Avoid the assumption that students enter the classroom with such skills.

- Don't try too much too soon. Start students working in pairs. It is nearly impossible for students to think about one thing and talk about another. Structuring interesting activities that require students to think and talk in pairs is a great way to introduce a collaborative model of learning.

- Don't give up! Provide lots of practice in working cooperatively on small, structured tasks for short periods of time before assigning open ended collaborative assignments.

- Keep groups as small as possible. Groups of no larger than four students are best to ensure engagement of all students. Structure groups carefully at first. Avoid self selection of groups.

- Groups should be as heterogeneous as possible to reflect diversity in achievement, ability, interests, and ethnic backgrounds.

- Plan the seating to facilitate group interactions and efficient transition from whole class to cooperative learning activities. Tables or flat topped desks grouped together are ideal.

- Establish a number system both for groups in the total class and for students within each group. Numbers may be laminated and taped to desks in the beginning. Strategically use these numbers in ways to invite participation for all groups, and for gentle reminders of adherence to standard operating procedures. Examples include: “Group #1 may share data now”: “Group #6 needs to clean their work area”.
Cooperative Learning/Collaborative Inquiry

Tips for successful implementation of cooperative learning/collaborative inquiry

Set standards and expectations for cooperative groups such as:

- Each student assumes responsibility for his/her own behavior.
- Each student is accountable for contributing to work of the group.
- Each student is expected to help any group member who needs it.
- Each student displays respect for peers and materials.
- Establish an “Ask three before me” rule. The teacher only gets questions that cannot be answered by someone in the class.
- Refer to groups as learning clubs or base teams. Routine dialog about the functioning of the team, with the targeting of skills to work on or develop, is an important tenet of cooperative learning/collaborative inquiry.
- Always ask student groups to evaluate how well their learning club or base team functioned and suggest ways they might improve.
- Group processing of social skills is important.
- Use short, written self-evaluation or peer evaluations of group functioning.
- Target specific skills, as needed, for teams or entire class to work to improve.
- Teacher observations of team functioning and sharing with what has been observed with the class, will focus on expectations for student and group accountability.
Teacher Notes:
Cooperative Learning/Collaborative Inquiry Strategies

Peer Reteaching
Teacher stops periodically during whole group instruction time and asks students to turn to their learning partner and “teach” him/her the content that has just been covered in class. Partners take turns being the teacher/tutee during subsequent stops for review and peer “reteaching”.

- Great for keeping students focused
- Reduces learning unit from a whole class-(easy to get lost in), to pairs- (It's harder to get lost or lose out on learning in a pair).
- Increases time on task
- Quick, easy, effective way to see if “students get it”

Think/Pair/Share
Teacher poses a higher order thinking question related to a unit. Students reflect on the question and write down their responses. Students then turn to a learning partner and share responses. Each learning partner then writes down something of interest that the other shared. If time allows, two pairs may team and share in a group of four.

- Works well as a strategy for sharing journal responses
- Works well with large classes, as it reduces learning unit from many to pairs
- Can be used to foster student thinking and reflection as follow up of a demonstration, discussion, videotape sequence, reading passage, and reporting out results or conclusions
- Provides time and a means for students to reflect on and verbalize understanding of concepts
- Fosters long-term retention of unit concepts
Cooperative Learning/Collaborative Inquiry Strategies

**Numbered Heads Together**
Each student in a group has a number from 1 - 4. Teacher presents a demonstration, asks a higher order question, or assigns a task. Students put heads together to brainstorm, answer a question, or complete a task enabling everyone in group to be “in the know”. Teacher randomly selects a number and asks students in each group having that number to be the reporter for that group.

- Reduces size of discussion group from whole class
- Builds interdependence
- Fosters important learning skills
- Creates the need for everyone in the group to “be in the know”

**Round Table**
A group of 3-4 students is given a problem to solve, a question to answer, or an activity to complete. The question should be one that requires discussion and higher order thinking. Each student considers the task and records his/her response in writing. The key is that only one sheet of paper and one pencil is used. No one is allowed to skip or pass a turn. Each group decides on the best answer from the group and shares this with the class.

- Requires collaboration
- Fosters interdependence among group members
- Useful for reviewing material or practicing a skill
Cooperative Learning/Collaborative Inquiry Strategies

Circle of Knowledge
Teacher poses a question with multiple answers. Students take turns offering an answer. No one is skipped. Team members may help a student think of an answer by either acting out, drawing a picture, or offering a verbal clue. A recorder is used to list student answers on a transparency, chart, or white board. Recorder can add a response to the list before sharing. All members sign list signifying that all participated in its creation. After a designated period, such as five minutes, teams share answers with another group or with whole class. Responses are written on board, transparency, or large poster for all to see. Start sharing with group that has compiled longest list. Other groups can challenge answers. The next group offers only those responses that differ from those shared by first group. Rewards such as leaving first at end of class may be offered to group with longest list of plausible responses.

- Great for either accessing prior knowledge or reviewing and reinforcing learning
- Each student has opportunity to participate and give support to group members if needed, to respond with a valid answer
- Fosters listening skills through the rule of “no repetition of similar ideas in either the brainstorming or sharing processes”
- Fosters creative thinking when students must find ways to provide “hints” to a peer without actually giving away a response

Team Learning
Use this format for rich experiences which may involve questions and/or learning tasks from reading passages, charts or graphs, or lab activities. All team members engage in discussion with team consensus required before the recorder writes. When work is complete, all group members sign the sheet indicating that they agree with responses on the sheet.

- Reduces learning and discussion unit
- Reduces number of papers teacher must grade
- Students build upon, constructively criticize, react to, and edit one another’s ideas
- Provides opportunity for students to verbalize thinking processes and learn from hearing the thinking processes of peers
Cooperative Learning/Collaborative Inquiry Strategies

**Jigsaw**
Base teams of 4-6 students are formed with each student being assigned a number. Students leave base groups and meet in assigned areas with students from other groups who have the same number. Each “expert group” studies provided materials consisting of one aspect of a problem, issue, or topic in order to become an “expert”. Ideas of how to share the information with others in the base groups may also be discussed in the expert group. Each student will be an “expert” on one aspect of the total issue, with the responsibility of mastering content and developing a strategy to teach others in the base group. After work in expert groups is complete, students return to base groups and share. Whole class sharing of the most important ideas or spotlighting teaching visuals might be a good close to this collaborative activity.

- Fosters accountability through use of “expert” role
- Promotes interdependence as everyone depends on “expert” for information
- Encourages communication skills
- Creates the need to summarize and identify main points
- Enables students to work together effectively to achieve a group goal
Cooperative Learning/Collaborative Inquiry Strategies

The Jigsaw Class
Divide the class period into quarters, such that one quarter of class time is spent in the counterpart group, two quarters is spent in the jigsaw group, and about one quarter is spent discussing main points and doing group processing of group skills.

- Divide students into jigsaw groups of 4-6 students.
- Students obtain their part of the jigsaw, consisting of an envelop with the information or an instruction card. Base groups separate into numbered, counterpart, “expert” groups.
- Students study with others in “expert” groups. They plan strategies for presenting and teaching the other students in their jigsaw group.
- Students return to their jigsaw group, present the learned material, and listen to the presentations of others. The jigsaw group leader keeps the group on task and monitors the time. At the end of the jigsaw session, students may prepare a group product, or group response to show that they’ve put together all the pieces of the jigsaw.
- The final step in jigsaw is to discuss main points, as a class, and process group cooperative skills.
Teacher Notes:
Cooperative Learning/Collaborative Inquiry Strategies

Teams-Games-Tournaments (TGT)
This strategy builds upon the positive interdependence of the base teams and that of individual accountability. Students “study and learn” a concept or skill in base groups. Students are numbered 1-4 with a level assigned to each number that is only known by the teacher. The number 1s from each group, number 2s from each group, number 3s from each group, and number 4s from each group reassemble at tournament tables. This is a great way to differentiate instruction. If group 1 is made up of above average students, then the questions that they answer would be above grade level. Recall 1 comes from each group. You would not want to form a base group of all above average. If the number 4s are below average, then the questions that they answer would be easier questions on the same topic. Students get points at the tournament table to take back to their base groups. All levels of students have the opportunity to compete at their level. This could also be used for instruction. If you know that a particular number of student is having difficulty, you can do a lesson “just for my 1s” or “just for my 4s”, while other students work on assignments.

- positive way to harness competitiveness
- provides a way to differentiate instruction
- works great for skills/vocabulary type worksheets

Games
The games are designed to test the knowledge gained from team study and teacher’s presentation of the material. A typical tournament game consists of between 25 and 30 questions. The answers are provided on a corresponding grid.

TGT Rules
The questions and answer grids are passed out to the equal ability teams. A set of teacher made cards are passed out with numbers that correspond with the number on the essential question sheet. A student picks a number card and attempts to answer the question that corresponds to the number. The first challenger challenges the answer if she or he wants to (and gives a different answer) or passes to the right of the student in control of the card. The second challenger challenges the answer or passes. When all have answered or passed, the second challenger reads the answer from the answer grid. Whoever was right keeps the card. If the reader, the one who picked the card originally was wrong, there is no penalty. If the challenger(s) were wrong, they must put back a previously won card, if any, in the deck.

Scoring the Tournament
Each student’s score is determined by the number of cards “won”. Team scores are determined by totaling each member’s score. Record these on a Team Summary Sheet and post on the bulletin board.
## Cooperative Learning/Collaborative Inquiry Strategies

### Teams-Games-Tournaments (TGT)

**T – G – T**

Sample Question Sheet

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is an M.M.U.?</td>
<td>2. Who was John Glenn?</td>
<td>3. What are the effects of weightlessness on the human body?</td>
</tr>
<tr>
<td>4. What is a space probe?</td>
<td>5. What was the name given to the program concerning the moon?</td>
<td>6. What was the name of the largest rocket ever built?</td>
</tr>
<tr>
<td>7. Define observatory</td>
<td>8. Define satellite.</td>
<td>9. What is the earth’s natural satellite?</td>
</tr>
<tr>
<td>13. What happened in 1958?</td>
<td>14. How are space probes launched into their orbit?</td>
<td>15. How has the exploration of space changed people’s lives on earth?</td>
</tr>
</tbody>
</table>
Teacher Notes:
# Cooperative Learning/Collaborative Inquiry Strategies

**Teams-Games-Tournaments (TGT)**

T – G – T  
Sample Answer Sheet

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2. The first American to orbit the earth</td>
<td>7. A building that is set up for the study of outer space.</td>
<td>12. Sputnik I</td>
</tr>
<tr>
<td>3. Calcium lost from bones - loose muscle strength</td>
<td>8. An object that orbits a larger object.</td>
<td>13. Explorer I was launched by the U.S.A.</td>
</tr>
<tr>
<td>4. A spacecraft sent out to gather data about the moon and the other planets.</td>
<td>9. Moon</td>
<td>14. Top of Rockets</td>
</tr>
</tbody>
</table>
Cooperative Learning/Collaborative Inquiry Strategies

Teams-Games-Tournaments (TGT)

Example of using TGT for differentiation of questions to match learning levels:

Tournament Table 1 Question #1
Beaker 1 contains 200 ml of water and 1 ml of an unknown chemical.
Beaker 2 contains 200 ml of water and 1 ml of an unknown chemical.
Beaker 3 contains 200 ml of water and 16 ml of an unknown chemical.
Which beaker has the highest dose?

Tournament Table 2 Question #1
Beaker 1 contains 200 ml of water and 1 ml of an unknown chemical.
Beaker 2 contains 200 ml of water and 4 ml of an unknown chemical.
Beaker 3 contains 200 ml of water and 16 ml of an unknown chemical.
Beaker 4 contains 100 ml of water and 4 ml of an unknown chemical.
Does beaker 2 or beaker 4 have the larger dose?

Tournament Tables 3 and 4

<table>
<thead>
<tr>
<th>Beaker number</th>
<th>Amount of water</th>
<th>Amount of chemical?</th>
<th>Total volume</th>
<th>% concentration of chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.00 ml</td>
<td>? Problem 1?</td>
<td>20 ml</td>
<td>0.0%</td>
</tr>
<tr>
<td>2</td>
<td>18.75 ml</td>
<td>? Problem 2?</td>
<td>20 ml</td>
<td>6.25%</td>
</tr>
<tr>
<td>3</td>
<td>17.50 ml</td>
<td>? Problem 3?</td>
<td>20 ml</td>
<td>12.5%</td>
</tr>
<tr>
<td>4</td>
<td>15.00 ml</td>
<td>? Problem 4?</td>
<td>20 ml</td>
<td>25.0%</td>
</tr>
<tr>
<td>5</td>
<td>10.00 ml</td>
<td>? Problem 5?</td>
<td>20 ml</td>
<td>50.0%</td>
</tr>
<tr>
<td>6</td>
<td>0.00 ml</td>
<td>? Problem 6?</td>
<td>20 ml</td>
<td>100%</td>
</tr>
</tbody>
</table>
Cooperative Learning/Collaborative Inquiry Strategies

Student-Team-Achievement-Division (STAD)

In Student Teams Achievement Divisions (STAD), individual accountability is the focus. Each student is competing with themselves to make improvement, as measured by quizzes. A base score is determined for each student, usually in the form of a pretest on the topic. As the school year passes, grades on other activities can serve to set new baselines so that you don’t have to pre-test continually. Students study together as base learning teams. This can take a similar format as TGT, where students use question and answer sheets in a cooperative setting after a presentation. Based on improvement, each student earns improvement points. The improvement points are earned like this:

Record base score (pretest) ________________

Point System for Individual Accountability
0 points= more than 10 points below base score
10 points=1-10 points below base score
20 points=if the same base score – 10 points above base score
30 points= more than 10 points above the base score
30 points=100% score

Point System for Team Achievement

Team Score=total improvement points of team members
2 points=Team total 0-50 improvement points
4 points=Team total 51-90 improvement points
6 points=Team total 91-120 improvement points
Cooperative Learning/Collaborative Inquiry Strategies

Student-Team-Achievement-Division (STAD)

<table>
<thead>
<tr>
<th>Name:</th>
<th>Class Period:</th>
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</table>

<table>
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<tr>
<th>Student-Team-Achievement-Division (STAD)</th>
<th>Date</th>
<th>Base Score</th>
<th>Quiz Grade</th>
<th>Improvement</th>
<th>Improvement Points</th>
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<tr>
<td>Pre-Test</td>
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</table>
Teacher Notes:
Cooperative Learning/Collaborative Inquiry Strategies

Student-Team-Achievement-Division (STAD)

TEAM SUMMARY SHEET for Improvement Points

<table>
<thead>
<tr>
<th>Team Name:</th>
<th></th>
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<th></th>
<th></th>
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<td></td>
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</tr>
<tr>
<td>TEAM MEMBERS:</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Total Improvement points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Team Score</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cumulative Score</td>
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</table>
Journals, Logs, and Notebooks in Science

Do your students keep journals, logs, or notebooks? What's the difference? What's important here is not what you call the product, but how you can best meld the merits of each type of writing to improve learning. Many teachers use a combination of the journal and log and call it a science notebook. The important thing is to provide a format for students to record data and reflections. Whatever the product is called show that students have or have not achieved the desired learning, if they have misconceptions, their reflections, their journey towards understanding a concept, and/or if more instruction is needed.

Journals = Reflections of student learning + writing is often initiated by a prompt + utilized after investigation is done
Logs = Recordings of data + utilized during and after the investigation
Notebook = Recordings of data + reflections about learning + utilized before, during, and after investigations

Some questions to consider when determining the structure for the notebook include:

- Are misconceptions being perpetuated?
- Do students record, in writing and drawings, an accurate account of the investigation?
- What level of questions are students recording about the investigation?
- Are the conclusions supported by evidence?
- What could be done to make the notebook more useful to students?
- Do students use their notebooks when presenting findings to the class?
- Do they provide evidence to explain their thinking?
- When are students making their recordings of data and reflections on their thinking?
- Which information do students choose to go into their notebook?
Teacher Notes:
Notebooking for Inquiry

Why Include Notebooks in Science Instruction?

Inquiry-based science instruction involves students in a variety of activities and uses multiple sources of information to explore curriculum concepts. Various student products, such as a lab report, inquiry paper, drawings, graphs, reading notes, etc., result. Notebooking provides a means of organizing student lab work and reflective thought processes. Students, in a sense, write their own personal book of explorations and understandings of curriculum concepts. Notebooks can include both log notes and final lab reports. Notebooks are good sources of review for tests. Notebooks are concrete and visible evidence of student thinking, effort, and progress. Writing requires the students to organize thoughts as they summarize, synthesize and reflect on what they have read or done. These skills are of such value that they warrant the time spent to teach notebooking.

- There are no “must dos” or absolute rules for science notebooking.
- Avoid the assumption that students bring the necessary organizational skills with them.
- Writing and science skills will be enhanced and practiced in notebooking.
- Notebooks improve over time.
- Notebooks provide important opportunities for all students to reveal, document, and show growth.
- Through notebooking, students can learn both science concepts and real world skills of organization, reflection, documentation, compiling evidence, and responsibility.
Notebooking for Inquiry

Tips for implementing Science Notebooking

- Decide on a format that works for your classroom. It may be a three ring binder, spiral notebook, stapled or folded papers. The important thing is to avoid loose papers.

- Decide what goes in student notebooks, such as:
  - Table of Contents,
  - Opening page of class expectations,
  - Lab Safety Rules,
  - Templates and instructions for:
    - Lab Reports,
    - Inquiry Papers,
  - Word Banks,
  - Notes from readings, and
  - Activity notes.

- Decide on a time frame for notebooks. They may be kept for any time period. (week, month, grading period, semester, year, through a unit, through a testing period)

- Gallon size zip lock bags can be used in loose leaf notebooks to store items, i.e., foldables, small models, flash cards. Punch holes in bag and add to the notebook like a sheet of paper.

- Contents of a unit can be removed from a binder, paper clipped and graded as units are completed.

- Keep a table of contents for current unit posted in classroom.
Notebooking for Inquiry

Tips for an Assessment System

- Explain the purpose of student science notebooks/journals.
- Set up a legend for the color-coding on the inside of the front cover of the students' notebooks. Explain the purpose and method of color-coding for the expected evidence in the notebooks.
  - Yellow denotes process
  - Green denotes explanation, conceptual understanding, principles
  - Blue denotes data and interpretation of data
  - Orange denotes visual representations
  - Pink denotes attitudes, interests, and feelings.
- Explain that it is important for a student notebook to have example entries that represent all of the colors.
- Explain that it helps the student if each label color is represented as many times as possible.
- Once the identified time for keeping a notebook related to an investigation or unit is up, students may use specific parts of the notebook for portfolio artifacts.
Class Starters

The first few minutes of class are critical. This is an ideal aspect of class management for which to make a standard operating procedure. Let students know what is expected of them when they enter your lab – to follow the directions for the Class Starter that are written on the board, on the overhead, in their groups on a card, etc. They KNOW what to do without you having to get them started.

**KWHL**
The K and W are used to access prior knowledge as an introduction to a new unit or topic of study. Sometimes showing an object or picture related to the new unit or topic will spur student thinking.
- K is what I think I know....
- W is what I wonder about....
- H is for how am I going to find out?...

After the lesson or unit and before the test, the student comes back to this notebook entry and completes the **L**.
- L is what I learned about

**Science Editorial Cartoon Reflection**
- What do you see?
- What symbols are used?
- What scientific issue/concept is being addressed?
- Is the issue represented accurately?
- What is the message?
- What is your opinion of the message?

**Discrepant Events**
Describe, draw and label exactly what you see. Make a series of drawings to illustrate observations. What is puzzling or unexpected. Make several hypotheses that might explain this discrepant event. Investigate to test each hypothesis. Discuss observations. Were some of the “observations” actually inferences?

Some starter ideas for discrepant events include:
- Have students research and/or suggest others. Dialogue about the science and misconceptions of science in all events.
- Floating sinking oranges (orange with peel, orange without peel in water)
- Floating sinking cans (identical cans of soda except one is diet)
- Floating sinking ice cubes (ice cubes in water, alcohol)
- Collapsing Can (Heat a small amount of water in a soda can. Use tongs to quickly turn can over in cold water.)
Class Starters

What Ifs?

What if we had to live without ____________________ (electricity, petroleum, computers, etc)?

What if everyone wanted to be a/an ___________ and no one wanted to be a/an ___________?

I Wonders

I wonder what the most important energy source of the future will be. It just might be _____ because...

I wonder what a colony on the moon would be like? I think it would ...

I wonder if life will be found on another planet and what it might be like?

If I...

If I were a scientist I would want to be a _____ because...

If I could explore another planet, I would want to explore _____ because...

If I could have lived in another geologic era, I would have wanted to live in the _____ because...

If I could create a cure for a disease it would be _____ because...

If I could invent a new machine it would be _____ because...

If I could write a letter to ________, I would say __________...
Class Starters

Explanations

Explain to ___________ (peer, parent, 5th grader, etc)

- how to use a ___________ (triple beam balance, graduated cylinder, thermometer).
- how to change a measurement from one metric unit to another.
- why changing from one unit to another is easier in the metric system than the English system.
- how to use a microscope.

Opinion prompts

- The US (should/should not) use the metric system as our official system of measurement because…
- The US (should/should not) increase funding for space exploration because…
- The US (should/should not) set a goal of landing a man on Mars because…
- The EPA (should/should not) relax air pollution standards because…
- The FDA (should/should not) require labeling of genetically engineered foods because…
- The US (should/should not) build more nuclear power plants…
- We (should/should not) restrict building along North Carolina coastal areas because…
- Billboards and commercial development along the Blue Ridge Parkway (should/should not) be restricted because…
Class Starters

Take A Stand
Have a statement written or posted for students to read as they enter the room. Have 4 signs posted: Strongly Agree, Agree, Disagree, or Strongly Disagree. Students must decide on their views and go stand near the corresponding sign. Students in each group prepare a 1 minute “plea” of why they took the stand that they did and present this orally. After each 1 minute plea, all students are allowed to change their stand and move to another group. Grade specific ideas for this class starter include:

6th Grade Statements
- There is a limited number of people earth can support.
- The benefits of space exploration outweigh the risks.
- Within the next 20 years, extraterrestrial life will be discovered on other planets.
- Due to erosion, the coastline of North Carolina will change drastically within the next 20 years.
- Recycling of our wastes is important to our environment.

7th Grade Statements
- If genetic engineering cured the world of diseases, it would that have a negative effect on world population.
- People today are healthier than they were 50 years ago.
- Pollution is causing global warming.
- Global warming is taking place.
- Everyone in our community is trying to improve air quality.
- Too much money and attention is being given to tracking storms, tornados, and hurricanes.

8th Grade Statements
- Global warming will have an impact on human life in the next 20 years.
- Restrictions imposed on corporations/factories for proper disposal of wastes has had a positive effect on soil and water quality.
- Drinking bottled water is better for you than drinking tap or well water.
- Overfishing of our oceans is taking place?
- The health of the world’s oceans is related to the overall health of the planet.
- Stricter use of antibiotics is important for public health.
- Money used for space exploration should be used for exploration of earth’s ocean.

Have students write statements related to current science events or a unit of study. Keep data on various class stands and do comparisons.
INQUIRY PAPER

Why Inquiry Papers Can be a Valuable Strategy

One of the goals of education is to create life long learners. Reading widely and critically is an important attribute of life long learners. Reading from a variety of sources is also important in building science vocabulary, deepening understanding of curriculum concepts, and enabling students to apply science concepts in different settings. Providing a print rich environment in the science classroom is important. However interesting strategies must be employed to encourage adolescents to explore and enjoy those resources.

Independent and self selected readings from newspapers, periodicals, fiction, and nonfiction books expose students to a wide variety of scientific ideas related to real world topics of interest to middle grades students. The more students read and encounter the vocabulary of science in context, the more able they will be to understand and apply science concepts. Such reading can help students connect science concepts to daily life and their interests. This structured writing activity requires students to study a reading carefully to comprehend what they have read and to create a short paper highlighting the main points of the reading. An additional learning opportunity is for peer reading and response to inquiry papers.

This strategy can be used both for teacher selected readings that build unit concepts or passages that are self selected according to student interest and reading level. Using multiple levels of reading materials is made easy with this strategy. It also works well as a strategy for student reporting of science news events on a regular basis. Another benefit of having students skilled in writing inquiry papers is that the structure and student focus required to complete this assignment makes the inquiry paper an excellent assignment for a substitute teacher. As with most strategies, the many effective uses of the Inquiry Paper are limited only by teacher creativity.
Teacher Notes:
INQUIRY PAPER

Tips for successful implementation of Inquiry Papers

- Provide each student with a copy of detailed instructions for format and requirements.
- Select some high interest readings of appropriate length to model and teach the format and expectations.
- Work with the whole class on creating an Inquiry Paper from the same reading. Read and model note-taking. Model the use of the notes to write an inquiry paper. Refer back to the passage as needed in the beginning.
- Practice writing papers in cooperative learning teams and/or in pairs.
- Have students prepare a computer template to use for the final draft on the inquiry paper.
- Establish peers or adults other than the teacher as the audience or reader for these papers to encourage writing in detail.
- Use peer editing as a means of building student familiarity with components of the inquiry paper and skill in writing them.
- After several inquiry papers are completed and shared as a class, students may select or be assigned different readings.
- Use a variety of sources for readings including newspaper articles and magazine articles.
- Make a file of such readings for each unit of study. Have students find readings to contribute.
- Work together as a team, as a science department, and as a school to be sure good quality materials are available.
- The newspaper and back issues of magazines from the media center of science magazines are good sources of articles to get started.
- Readings may be selected to support a unit of study, to study current issues in science, to relate science to daily lives of students, or be self selected by students.
- Inquiry papers may be exchanged, read, and responded to as an additional learning activity for students.
- Other teachers, parents, and students in other grades and classes may also read and respond to Inquiry Papers. This is a good way to recognize a student who has done an exceptional job on an assignment whatever the reading level of the original passage.
- Teach students to honor copyright laws.
- The internet provides a wealth of searchable information to use with this strategy
- Adapt this activity to meet the needs of your students.
Teacher Notes:
Inquiry Paper Outline

**Source**
Use correct bibliographic format

**Topic**
One or two words that summarize what the reading is about

**Main Idea**
One sentence that summarizes the big idea of what the author has written about the topic.

**Supporting Details**
Three or more numbered sentences giving specific details or facts that the author uses to develop the main idea.

**Visual**
An illustration, drawing, or graphic organizer that clarifies an important idea or relationship in the reading. Use labeling and color as needed to make visual more effective.

**Key Words**
A list of at least 5 key words in the reading. Define words from context clues or word parts if possible. Use a dictionary or glossary only after exhausting other strategies.

**Summary Paragraph**
A good paragraph that provides the reader with a complete and accurate summary of the author’s ideas. Use main idea and supporting details to build paragraph. Use and circle key words in writing paragraph.

**Questions**
Three good questions you are left wondering about after careful study of the reading.
Teacher Notes:
Inquiry Paper Reader Response Outline

Bibliographic Information —

Inquiry Paper Author —

Date of Paper —

Peer Reader Response —
Date —
Name —

Positive feedback —

Personal Reflection —
(May be a question, a possible answer to a question posed in the paper, suggestions for further reading/study

Signature of Reader
Title
(peer, parent, other teacher, administrator, etc.)
Teacher Notes:
## Inquiry Paper

### Rubric for Science Teacher Evaluation

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<tr>
<th>Inquiry Paper Components</th>
<th>Yes</th>
<th>No</th>
</tr>
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<tbody>
<tr>
<td>Bibliographic Entry</td>
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<td></td>
</tr>
<tr>
<td>Main Idea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting Details</td>
<td></td>
<td></td>
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<tr>
<td>Visual</td>
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<td>Key Words</td>
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<td>Summary Paragraph</td>
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<tr>
<td>Questions</td>
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<tr>
<td>Summary Comments</td>
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</table>
# Inquiry Paper

**Review Form**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Possible Points</th>
<th>Earned Points</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bibliographic Entry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete and correct format</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Main Idea with Supporting Details</strong></td>
<td></td>
<td>15</td>
<td></td>
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<tr>
<td><strong>Visual</strong></td>
<td></td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Appropriate for information</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Meaning is clear</td>
<td></td>
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</tr>
<tr>
<td><strong>Key Words</strong></td>
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<td>20</td>
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</tr>
<tr>
<td>Five words with Acceptable Definitions;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used in the paper</td>
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<tr>
<td><strong>Summary Paragraph</strong></td>
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<tr>
<td>Clear, concise; At least six original,</td>
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<tr>
<td>meaningful sentences; Develops main</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>idea and supporting details;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrates understanding of reading</td>
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</tr>
<tr>
<td><strong>Questions</strong></td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>At least three thoughtful ones</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related to topic and to science</td>
<td></td>
<td></td>
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<tr>
<td>Demonstrate understanding of reading</td>
<td></td>
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</tr>
<tr>
<td><strong>Format</strong></td>
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</tr>
<tr>
<td>Sections listed and underlined</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Line skipped between sections</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Neat and legible</td>
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<tr>
<td><strong>TOTAL POINTS</strong></td>
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<td>100</td>
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</table>
Article Review

Name __________________________

In your own words, what’s it about?

Date

Source

What’s the MAIN idea?

Supporting Details/Facts/Evidence used by the author to develop the main idea
Teacher Notes:
Article Review

Author’s Point of View?  Bias?  Author’s Purpose?

Word List

Meaningful Sentences
Summarizing and Notetaking

Communicating one’s thoughts verbally and in writing are important, regardless of the content being addressed. Science teachers can no longer leave instruction in reading, writing, and note-taking to language arts teachers. Marzano’s review of three decades of educational research finds that teaching summarizing and note-taking skills a strategy that teachers can use to increase student achievement in all content areas. Teaching these skills and providing time for students to have pair or mentor reading to practice these skills is a more effective strategy, than the typical reading aloud.

**Oral round robin reading of the textbook may fill class time, but it does little to fill adolescents with a love of science or an understanding of important science concepts.** Use of class time in which students are involved in more active thinking and learning, results in higher student achievement. Exploring some of these strategies can decrease concern about time on task and discipline.

**Tips for success in reading comprehension of scientific information**

- Set a clear focus for reading with an essential question.
- Plan a pre-reading activity for each reading assignment to activate prior knowledge. Use a graphic organizer to record information.
- Model strategies for students, then allow learning groups to work together to practice the strategy, and then expect students to individually use the strategy.
- Reading in the textbook should always follow the exploration phase of instructional design.
- When reading science text for information, help students form the mindset that “one reads with a pencil”.
- Use various types of materials for reading scientific information.
- Strive to utilize the textbook as a reference material and one of many equally viable sources of reading materials used in the inquiry-based learning environment.
Teacher Notes:
Summarizing and Notetaking

Tips for success in reading for science information

- Point out text features, such as bullets, bold print, charts, maps, graphs, diagrams, titles, and captions. Discuss what can be learned about essential question from these features.

- Provide an interest hook for new vocabulary words in the reading.

- Read to students and model how to “think aloud” during reading.

- Read to students and model many different ways of taking notes on white board or the overhead transparency.

- Have peers read, take notes, and write summaries as a learning group.

- Have individual students read, take notes and/or summarize readings. Ask questions that students can get credit for only if the response is in the notes or summary of the reading.

- After skills have been taught and practiced, require individual reading, note taking and/or summarizing for all readings.

T-Charts
Have students fold a sheet of paper in half length wise. Label with title and pages of reading. Using title, pictures, diagrams, etc, students write a sentence predicting what important science ideas may be in the assigned reading. Label left side of paper, “The author says”. On this side, students jot down notes from reading. Label right side of paper, “My thoughts and questions”. On this side, students write questions, comments, draw diagrams, define new vocabulary, etc. The right side notes may be anything that indicates student has processed and interacted with the passage.

Draw What You Saw! Ink What You Think
At end of week or unit, have students use half of a journal page to draw an illustration to represent an important science concept or idea encountered during that week or in that unit. The other half of page is used to write a good paragraph summarizing what was learned about that concept. Have students use and circle as many new science words as possible.
Summarizing and Notetaking

QAR – Question and Answer Relationship
This strategy is based on research that found that students that understand how questions are written do better in answering questions than students who lack this understanding. (Raphael, 1982) The QAR strategy encourages students to use both information from the text and their prior knowledge. Students create questions from a reading passage that resemble those on unit or standardized tests. Students write four types of questions on sticky notes, note cards, or paper.

Classify and post questions on board under proper type of QAR types of questions.

- **“Right There”**
  The words in the question are right there with the answer in one sentence. Answer is simple recall/literal interpretation. This answer could be underlined in the reading passage.

- **“Think and Search”**
  Information must be synthesizes from various parts of the reading passage. The answer is in the passage, but one must draw from different parts (several sentences or paragraphs) to put an answer together.

- **“Author and You”**
  For this category, prior knowledge must be combined with information from the reading passage. This question can only be answered by using background knowledge. Information in the passage must be combined with what the learner already knows. The learner must decide how it all fits together in order to answer question.

- **“On My Own”**
  Information is not there. The answers to these questions are not in the passage but relate to it. These questions might be answered without reading the passage, but make more sense when considered with the passage. These questions are those that might be asked before reading a passage in order to bring out prior knowledge.

Power Outlining 1, 2, 3
This is a process of outlining that enables students to organize information for a quick review of the main points.

- Step 1 is the main idea.
- Step 2 is supporting details for the main idea.
- Step 3 is an extended discussion of specific details.
Mnemonic Devices

Create a nonsense sentence that would help one remember a list such as:

- The order of the planets from the sun
  (My Very Energetic Mom Just Sent Us Nine Pizzas)

- Prefixes in the metric system
  (Kangaroos Hop Down Bumpy Driveways Crushing Marshmallows).

- The order of operations in mathematics
  (Please Excuse My Dear Aunt Sally)

Start by sharing a mnemonic device with students and having them create original ones for the same list. Later give a list or order of something and have students do the same thing. Illustrating these or making posters adds to the recall of the lists.
Teacher Notes:
Foldables

Use the 2s foldable technique to illustrate:

- Advantages – Disadvantages
- Pros – Cons
- Agree – Disagree
- Past – Present
- Cause – Effect
- Similarities – Differences
- Prediction – Outcome
- Qualitative – Quantitative
- Facts – Opinions
- Before X – After X
- Above – Below
- Form – Function
- Fahrenheit – Celsius
- Homogeneous – Heterogeneous
- Exothermal – Endothermal
- Organic – Inorganic
- Plant Cell – Animal Cell
- Hibernation – Estivation
- Dominant Traits – Recessive Traits
- Chemical – Physical
- Input – Output
- Conductors – Insulators
- Solar – Lunar
- Surface Water – Ground Water
- Acid – Base
- Primary – Secondary
- Mass – Volume
- Mass – Weight

Do a “hot dog” fold. Write the topic/concept across the top of the fold. Cut the front fold in half to the fold line. Write one word on each half. Fold the cut flaps upwards to write appropriate responses and draw visual representations/illustrations.
Teacher Notes:
Science Vocabulary Development
Science vocabulary, with its many technical and specialized terms, can be a barrier to successful reading comprehension of science information. Science can seem like a foreign language, when many new words are introduced one after another and/or when common words have new meanings. Building a strong science vocabulary takes time, effort, and a variety of experiences with words. Research makes the case for systematic instruction in vocabulary. (Marzano, 2001) Research also supports the idea that vocabulary study should not be devoid of experiences and explorations.

Vocabulary development goes far beyond copying and memorizing definitions from the textbook glossary. In fact, such traditional ways of introducing new words, probably does little to build scientific understanding or vocabulary. Wide reading of different kinds of science material is one of the easiest and best strategies for vocabulary building. This allows students to see words used in context. In addition to wide reading, however, Marzano cites research that supports direct instruction on words, that are critical to new content, as a powerful means to increase achievement. New and varied strategies, that emphasize similarities and differences, are needed to build science vocabulary. Studying Greek and Latin roots used in science vocabulary can be interesting. Asking students to create images of new vocabulary can build vocabulary. Such strategies are designed to turn students into “word detectives”, to build curiosity about language, and to understand how to gain meaning when dealing with specific science words.

Concept Development
Developing a robust understanding of science, goes far beyond learning to pronounce and “define” key words. Being able to recite a definition is not the same as understanding the science concept and vocabulary. Concept development involves mental images, properties, and processes. Design instruction so that students understand the concept first, and then, attach a vocabulary label, if desired, to these mental images, properties explored, or processes investigated.
Science Vocabulary Development

Student Identification of Key Vocabulary

- Have students groups review a variety of media related to a new unit.
- Have each group identify words that they associate with a given topic or unit of study. Compare for overlaps and revisit list after explorations.
- Require students to use vocabulary in lab reports and inquiry papers.

Eyes on Vocabulary Words and Images
Write important vocabulary words that are similar in meaning and/or spelling on large strips of paper, i.e., qualitative and quantitative. These words can be illustrated with images that differentiate meaning, qualitative – eye, ear, nose, hand and quantitative – balance, ruler, clock. Challenge student groups to create vocabulary images and post these to bombard students with visual images to build word meaning.

Science Spelling Bees
Use white boards to conduct group science spelling bees for key vocabulary. Ask students to pronounce and spell word, define it, use it in a sentence, and/or draw a picture of it. Being able to associate a picture or image with a term is a powerful way to construct a meaning for that term. Research cites nonlinguistic representations, as another key strategy, for raising student achievement. Brain research indicates that images, pictures, and diagrams are brain friendly and thus contribute to increased understanding and retention. (Marzano, 2001)

Words with special meanings in science
Keep a class list of words that have different and special meanings in science when compared to how the words are used in everyday life. Make a chart with the science meaning and the everyday meaning of each word. Have students create a diagram or illustration to show different meanings for common words when used in science, i.e., property, plate, or work.
Teacher Notes:
Science Vocabulary Development

Word Webs for analyzing word parts (prefix, root words, suffixes)
Groups draw, select, or are assigned a science word part. Print root, its meaning, and its origin in the center of a transparency or chart paper. Circle the root. Brainstorm words related to the root and record so they branch out from the circle like a web. A student definition should be written for each word in the web. Use the power of color. Use “ology” to model this strategy. Challenge students to come up with prefixes for this word part. Define and categorize new words into natural, social, and pseudo sciences. This would also yield an opportunity to address what defines science itself.

Vocabulary Trees
Draw a large outline of a tree that fills a page. At the base of the tree, write a root word and its meaning. Add at least 6 lines representing limbs. On each limb, build a word by combining the root word with another science word part. Define and illustrate the new words. Use “meter” to model this strategy. Challenge students to brainstorm things that measure, i.e., thermometer, barometer, seismometer. Break words into word parts and determine the meaning of the parts. Use six of the words to make a word tree.

Wild and Wacky Words
Combine two word parts to make a new nonsense word. Encourage creativity. The “wilder and wackier” the word, the more likely students are to remember the word parts. Literally define the nonsense word and illustrate. Label with the word parts and meanings. Have students check the dictionary to make sure the word is not a real word. i.e., “octopod” might be illustrated as a spider or a “tripod” could be a three legged dog.

Science Acronyms
Write a key word that represents a major science concept vertically down a page. Each letter of the word is then used as the beginning of a sentence or phrase with information related to the concept. The thinking required in completing this activity requires students to review principles and processes they have studied in a unit. Sharing of acronyms in small groups allows for students to question or suggest edits for each line. Have some acronyms made into classroom posters. Use for year end review of important concepts.
Science Vocabulary Development

Classifying and Grouping Vocabulary
Students create word webs to show relationships of key vocabulary terms in a unit. Model this strategy if students have had little experience with webbing. Over time students can develop webs in pairs or learning clubs. Sharing webs that have been created with the same words is interesting for students. Students can add drawings or illustrations to webs. This nonlinguistic element makes review of vocabulary more interesting and valuable to learners.

“Jeopardy” Concept Review
This strategy uses the answer-question format, based on the game of Jeopardy as another way to review major concepts. This strategy works well with cooperative learning groups. Challenge students to come up with different “questions” for this answer. Strategy framework: The ANSWER is ________________. What is the question?

Frayer Model
The Frayer Model (Frayer, Frederick, and Klausmeier, 1969) was designed to present concepts by looking beyond definitions. Students are required to identify relevant and irrelevant attributes, examples and nonexamples, superordinate, coordinate, and subordinate aspects of concepts. The thinking required to complete a Frayer Model improves understanding and long term retention of information. Extended, whole-class modeling of this strategy is needed before students do them on their own.

<table>
<thead>
<tr>
<th>Essential Characteristics</th>
<th>Nonessential Characteristics</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Examples</th>
<th>Non-examples</th>
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<tbody>
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<td></td>
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</table>
Teacher Notes:
# Science Vocabulary Development

**Frayer Model for a CONCEPT**

<table>
<thead>
<tr>
<th>Definition (in own words)</th>
<th>Characteristics</th>
</tr>
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<tbody>
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</table>

<table>
<thead>
<tr>
<th>Examples (from real world)</th>
<th>Non-Examples (from real world)</th>
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</table>

**Concept**

**Frayer Model for Word Analysis**

<table>
<thead>
<tr>
<th>Common Characteristics</th>
<th>Definition</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Examples</th>
<th>Related Words</th>
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<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
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</table>
Science Vocabulary Development

Frayer Model for an Analogy

<table>
<thead>
<tr>
<th>Like or Compare to (x:y)</th>
<th>Unlike/Contrast (x:y)</th>
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</thead>
<tbody>
<tr>
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</table>

Examples/Illustrations (x and y)

_________________:_________________   as   __________________:_________________

Analogies
From Marzano’s review of educational research, identifying similarities and differences was identified as a strategy for increasing achievement. Metaphors and analogies are interesting ways to compare things that seem very different, yet have some similarities, when carefully considered. Analogies take the form of x: y :: a:b. This is read as “x is to y as a is to b”

Provide students with the analogy and ask students to explain the relationship, i.e., sun: solar system as nucleus: atom. Omit one part of the analogy and ask students to complete the analogy, i.e., Dalton is to the atomic theory as Darwin is to ____________.

Even more powerful are analogies both created and explained by students. Review of research indicates that using a graphic organizer, with the creation of analogies, can be the most powerful manner in which to use this strategy for increasing student achievement.
## Rubric for Experimental Design – Title of Investigation

| Category                  | Student Assessment                                                                 | 3                                      | 2                                      | 1                                      | 0                                      | Teacher Assessment                   |
|---------------------------|-------------------------------------------------------------------------------------|----------------------------------------|----------------------------------------|----------------------------------------|----------------------------------------|
| Question /Purpose         | Clearly identified and stated                                                        | Stated but unclear                     | Partially identified and unclear       | Not identified, erroneous, or irrelevant |                                        |
| Experimental Design       | Well constructed test of stated hypothesis                                          | Adequate to test hypothesis but leaves unanswered questions | Relevant to hypothesis, but not a complete test | Not relevant to hypothesis             |                                        |
| Variables                 | Clearly described with thorough details                                              | Clearly described with most details    | Unclear                               | Lacks details                          | Not described                          |
|                           | Sequential outline                                                                  | Procedures appear replicable            | Steps outlined                         | Steps outlined but lacks some details for replication | Steps missing, Lack sufficient detail  |
| Replicability             | Procedures appear replicable                                                         | Some detail                            |                                        |                                        |                                        |
| Error Analysis            | Errors, effects, and ways to reduce are discussed                                   | Errors and effects are discussed       | Errors are mentioned                   | Not mentioned                          |                                        |
|                           | Professional appearance and accurate representation of data                         | accurate representation of data       | accurate representation of data in written form |                                        |                                        |
|                           |                                                                                     |                                        |                                        |                                        |                                        |
| Data                      | Supports hypothesis, sources of error, what was learned                              | Supports hypothesis                    | States what was learned                | No conclusion or shows little reflection |                                        |

Date of lab: ___________________  Due date: ___________________
### Rubric for Experimental Design – Title of Investigation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>3 Through and Complete</th>
<th>2 General Grasp Minor Errors</th>
<th>1 Poor Grasp Major Errors</th>
<th>0 Unrelated or Inappropriate</th>
<th>Student Self-Assessment</th>
<th>Home Assessment</th>
<th>Teacher Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifies problem</td>
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<td>Formulates hypothesis</td>
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<td>Controls for variables</td>
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<tr>
<td>Materials</td>
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<tr>
<td>Logical procedure</td>
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<td>Accurate measurement</td>
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<td>Clear, orderly collection of data</td>
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<tr>
<td>Graph type appropriate for data display</td>
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<td>Graph titled and axis labeled</td>
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<tr>
<td>Use of units</td>
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<td>Procedure could be replicated</td>
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<td>Sample size or number of trials sufficient</td>
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<tr>
<td>Data Analysis</td>
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<tr>
<td>Data Based Conclusion</td>
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</tbody>
</table>
# Rubric for Technological Design – Title of Design

<table>
<thead>
<tr>
<th>Criteria</th>
<th>3 Thorough and Complete</th>
<th>2 General Grasp Minor Errors</th>
<th>1 Poor Grasp Major Errors</th>
<th>0 Unrelated or Inappropriate</th>
<th>Student Self-Assessment</th>
<th>Home Assessment</th>
<th>Teacher Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identified a problem appropriate for technological design</td>
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<tr>
<td>Developed criteria for evaluating the product or solution</td>
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<td>Identified constraints that must be taken into consideration</td>
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<td>Designed a product or solution</td>
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<td>Logical procedure used</td>
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<td>Accurate measurements</td>
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<tr>
<td>Clear, orderly collection of data</td>
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<td>Graph type appropriate for data display</td>
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<tr>
<td>Evaluate completed design or product by criteria developed</td>
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<tr>
<td>Analyze the risks and benefits of the solution</td>
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<tr>
<td>Procedure could be replicated</td>
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<tr>
<td>Number of trials sufficient</td>
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<tr>
<td>Able to communicate the process of technological design</td>
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<tr>
<td>Reviewed and revised the design</td>
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</tbody>
</table>

Name ______________________ Date of lab ______________________ Due date ______________________
Teacher Notes:
## Rubric for Biography of a Scientist

<table>
<thead>
<tr>
<th>Categories</th>
<th>Possible Points</th>
<th>Points Earned self evaluation</th>
<th>Points Earned peer evaluation</th>
<th>Points Earned teacher evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Paragraph 1</strong>&lt;br&gt; - Is the reader made aware of the:&lt;br&gt; - Birth date, family information, city or country of residence, education information, and events or situations that contributed to this person’s success?</td>
<td>15</td>
<td></td>
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</tr>
<tr>
<td><strong>Paragraph 2</strong>&lt;br&gt; - Is the reader made aware of this person’s contributions to science?</td>
<td>25</td>
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<td></td>
</tr>
<tr>
<td><strong>Paragraph 3</strong>&lt;br&gt; - Is the reader made aware of what you learned about this person and his/her contributions to science?</td>
<td>25</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Paragraph 4</strong>&lt;br&gt; - Is the reader made aware of the resistance or acceptance of the work of this scientist met?</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Paragraph 5</strong>&lt;br&gt; - Is the reader made aware of how this scientist’s work impacts you personally?</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grammar</strong>&lt;br&gt; - Correct punctuation, capitalization, spelling, word order and choice, variety of sentence types used, and sources cited</td>
<td>5</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Neatness</strong>&lt;br&gt; - overall appearance</td>
<td>5</td>
<td></td>
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<tr>
<td><strong>Totals</strong></td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td>Objectives</td>
<td>Teacher Activities</td>
<td>Student Activities</td>
<td>Assessment</td>
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<tr>
<td>-------</td>
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</tr>
<tr>
<td>4</td>
<td>All objectives are clearly written in words and numbers and are aligned with the SCS.</td>
<td>All teacher activities are varied from lesson to lesson and all activities are consistent with best practices.</td>
<td>All student activities are varied from lesson to lesson and all activities are based on best practices.</td>
<td>All assessments are varied from lesson to lesson. All foster feedback and are aligned with instruction.</td>
</tr>
<tr>
<td>3</td>
<td>Most objectives are clearly written in words and numbers and are usually aligned with the SCS.</td>
<td>Most teacher activities are varied from lesson to lesson and most activities are consistent with best practices.</td>
<td>Most student activities are varied from lesson to lesson and most activities are consistent with best practices.</td>
<td>Most assessments are varied from lesson to lesson. Most foster feedback and are aligned with instruction.</td>
</tr>
<tr>
<td>2</td>
<td>Some objectives are clearly written in words and numbers and are sometimes aligned with the SCS.</td>
<td>Some teacher activities are varied from lesson to lesson and some activities are consistent with best practices.</td>
<td>Some student activities are varied from lesson to lesson and most activities are consistent with best practices.</td>
<td>Some assessments are varied from lesson to lesson. Some foster feedback and are aligned with instruction.</td>
</tr>
<tr>
<td>1</td>
<td>Few objectives are clearly written in words and numbers and few are aligned with the SCS.</td>
<td>Few teacher activities are varied from lesson to lesson and few reflect best practices.</td>
<td>Few student activities are varied from lesson to lesson and few reflect best practices.</td>
<td>Assessments are one type and do not foster feedback and are not aligned with instruction.</td>
</tr>
</tbody>
</table>
Self-Assessment – Group Project

Group ________________________ Date ________________________
Project ________________________

Use these descriptors to assess how effectively your group performed a specific activity. Choose one or several numbers from the list of criteria: 1=not evident  2=we think so  3=needs improvement  4=satisfactory  5=clearly evident  N/A=did not apply.

<table>
<thead>
<tr>
<th>CATEGORIES</th>
<th>Self-evaluation</th>
<th>Group evaluation</th>
<th>Teacher evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did we review safety information before we started?</td>
<td></td>
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<tr>
<td>Did all members of the group contribute to the research and final project?</td>
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<tr>
<td>Did we thoroughly research the topic?</td>
<td></td>
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<tr>
<td>Did we discuss the purpose for the project?</td>
<td></td>
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<tr>
<td>Did each group member have a specific role or task?</td>
<td></td>
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<tr>
<td>Were we able to work together for this investigation?</td>
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<tr>
<td>Did we develop a plan before we began our work?</td>
<td></td>
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<tr>
<td>How well did our end product match our plan?</td>
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<td></td>
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</tr>
<tr>
<td>Did we cite credit for resources used?</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Did we include quantitative data as evidence?</td>
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</tr>
<tr>
<td>Did we include qualitative data as evidence?</td>
<td></td>
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<tr>
<td>Were data evaluated to search for its meaning?</td>
<td></td>
<td></td>
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<tr>
<td>Did we use the appropriate techniques for data analysis?</td>
<td></td>
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<tr>
<td>Was the final product supported by the evidence we collected?</td>
<td></td>
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<tr>
<td>Did we revise our original plan?</td>
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<tr>
<td>Did we discuss questions that we still have?</td>
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<tr>
<td>Did we clean up thoroughly after the project?</td>
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<tr>
<td>Did we make plans on how to best communicate our findings?</td>
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<tr>
<td>OTHER:</td>
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</tbody>
</table>
Careers

What's an Ecotect?
Purpose: To allow students to consider that scientific jobs of the future may not even exist today

Everyone knows what a chauffer is and could describe what that job is like. We have all seen gas trucks delivering gasoline to gas stations. But less than 100 years ago, before the automobile became popular, these jobs did not exist. See if you can describe some possible future jobs. Select 15 job titles from those listed below and write a job description for each. Then, make up 5 names and job descriptions for jobs in the future.

Biorhythm Engineer  Greenspace Engineer
Sea Herder           Experience Agent
Mechbrain Analyst    Leisure Banker
Risk Rater           Host Mother
Green Cross Worker    Z-Ray Operator
Attendant Watcher    Robo Jockey
Sono Guide           Home Spinner
Laser Architect      Life Decision Advisor
Skysitter            Future Shock Therapist
Bionic Therapist     Soil Searcher

(Adapted from http://col-ed.org/cur/sci/sci65.txt)
# Careers

Directions: Choose a career that interests you. Complete three activities in a row of your choice (vertical, horizontal, or diagonal)

<table>
<thead>
<tr>
<th>Prepare a “Help Wanted” advertisement for your chosen career.</th>
<th>Interview a person who presently has this career that you have chosen.</th>
<th>Gather the mean and median salary of your chosen career.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and list high school and college requirements for chosen career.</td>
<td>Develop an oral presentation - five minutes or less that will acquaint other students with your chosen career.</td>
<td>Investigate proper attire for your chosen profession. Display a picture of their attire.</td>
</tr>
<tr>
<td>What geographic area could your chosen career be found? How do you know?</td>
<td>Complete a job profile. List exactly what a person who has this career does for a living. What are the pros/cons of having this career?</td>
<td>Using the gathered salary information, develop a balanced budget for an individual living on their own.</td>
</tr>
</tbody>
</table>
Character Wheel

Draw a large wheel with a center hub. Write the name of the scientist on the hub and character traits you can associate with the scientist. Provide a rationale as to why you selected each trait. Decorate the wheel with illustrations of this scientist's accomplishment.

- Honest
- Light-hearted
- Leader
- Expert
- Brave
- Conceited
- Mischievous
- Demanding
- Thoughtful
- Bright
- Courageous
- Serious
- Funny
- Humorous
- Sad
- Poor
- Rich
- Tall
- Dark
- Keen
- Humble
- Friendly
- Short
- Adventurous
- Hard-working
- Timid
- Shy
- Bold
- Daring
- Pitiful
- Cooperative
- Lovable
- Prim
- Proper
- Ambitious
- Able
- Quiet
- Curious
- Reserved
- Pleasing
- Bossy
- Witty
- Fighter
- Tireless
- Energetic
- Cheerful
- Smart
- Impulsive
- Loyal
- Dainty
- Happy
- Disagreeable
- Simple
- Fancy
- Plain
- Excited
- Studious
- Inventive
- Creative
- Thrilling
- Independent
- Intelligent
- Compassionate
- Gentle
- Proud
- Wild
- Messy
- Neat
- Light
- Handsome
- Pretty
- Ugly
- Selfish
- Unselfish
- Self-confident
- Respectful
- Considerate
- Joyful
- Strong
Research Advisor Activity
Scientists require funding for almost all the work they do, ethics and values play an important role in determining which research receives funding.

Imagine that you are a scientist who has been selected to advise a government agency that provides funds to support scientific research. You have been sent the following brief abstracts of 9 proposed research projects that have been submitted to the agency. Read the abstracts carefully and then rank each one on a scale of 1 to 9 – where 9 is the lowest favorable – with respect to the listed criteria.

Criteria = Extent to which you think the research:

- is important.
- may result in public benefit or harm.
- is necessary for the advancement of science.
- is likely to improve the country's economy.
- is likely to affect the environment.
- is important for the government to support.
- results may justify the cost.

Additional activities: Have students write the reasons why they would or would not fund each of the proposals.
I would (would not) fund this research project because ...

Additional activities: Assign each group a proposal. Have them present it to the class as a proposal, addressing the items in the criteria list. Have the class select the funded projects (maybe 3 out of the 9) based on the presentations.
Use the format in the Strategy “Original Research Proposal.”
Teacher Notes:
Research Advisor Activity

RESEARCH PROPOSAL: Development of High Energy Rocket Fuel for Mission to Mars
The National Aeronautics and Space Administration (NASA) has proposed sending a series of manned rocket ships to Mars in order to establish a permanent space colony there within the next decade. This proposed research would examine the combustion properties of a newly discovered group of high energy chemicals that can be made from coal and other plentiful raw materials. The goal would be a more energetic rocket fuel that would allow the Mars spaceships to carry a larger payload.

RESEARCH PROPOSAL: New Artificial Kidney
A new type of plastic shows promise of being used as a thin film in an artificial kidney that can filter and cleanse blood just as effectively as a real kidney. This proposed research would test the ability of this plastic film to filter all of the poisons out of human blood that are filtered out by a real kidney. Human volunteers who are waiting for kidney transplants will be used in this research. The plastic material is extremely expensive so, if the research is successful, the artificial kidneys will cost more than a kidney transplant, but those that can afford them won't have to wait for the availability of kidneys that matches their blood types.

RESEARCH PROPOSAL: Genetically Engineered Tobacco
A variety of tobacco has been developed by selective breeding techniques which contains only half the nicotine and tar of the average tobacco plant. This new variety is very expensive to grow because it is not as resistant as other varieties of tobacco to several insect pests. This research is designed to perfect a technique of incorporating into the new low nicotine and tar variety the gene that makes other varieties resistant.

RESEARCH PROPOSAL: Migratory Behavior of the Humpbacked Whale
Efforts to protect the humpbacked whale from pollution and from its predators have been made difficult by the fact that not enough is known about this species migratory behavior. This proposed research will use a small electronic device that can be attached to the whales' back with no ill effects to track the whales as they move between their summer and winter feeding areas and to determine where they go to mate and raise their young.

RESEARCH PROPOSAL: Protecting a Government DNA Data Bank
A small sample of blood or loose skin from any human being can be used to obtain a DNA "fingerprint" that is a virtually infallible way of identifying that individually from a future sample obtained from that same person. The government would be able to use a computer data bank of stored DNA information from all U.S. residents for many purposes such as tracking down criminal suspects, identifying missing persons, positively identifying people for income tax and social security purposes, etc. One problem with the scheme is that the data bank would need to be available only to those authorized by the government to use it. This research is aimed at finding ways of protecting such a data bank from access by unauthorized computer hackers.
Research Advisor Activity

RESEARCH PROPOSAL: Testing an Experimental AIDS Drug On Rhesus Monkeys
A potentially highly effective new drug for the treating AIDS patients has been developed. There is concern however that this drug may have several severe side effects in humans that would not occur in the usual laboratory animals like mice and rats in which it has been already tested. Before it is tested on humans this research proposes to test it on Rhesus monkeys. These monkeys, although rare and expensive have been used in research in the past because they are often very similar to humans in their toxic responses to drugs.

RESEARCH PROPOSAL: Effects of Eating Fast Foods on Health
Fatty, high cholesterol, foods have been blamed by health scientists for increasing obesity and susceptibility to heart disease in the public. Scientists who disagree with this assertion propose to provide food from McDonalds, Burger King, Pizza Hut, KFC and other fast food restaurants to elementary school children in ten low income neighborhoods in New York, Chicago and Los Angeles. By following the health of these children over the following twenty years they hope to disprove the allegation that fast foods cause poor health.

RESEARCH PROPOSAL: Development of Disposable Business Clothing
One of the inconveniences for frequent business travelers is the need to constantly pack and unpack clothing. Textile scientists have proposed testing the use of a very cheap new fabric that they think can be adapted to the production of shirts, suits, underwear, dresses and virtually every other essential item of clothing. Their goal is to demonstrate that such clothing can be produced in such a cheap manner that a business traveler could simply purchase new clothes at his or her destination and throw them out when the trip is over.

RESEARCH PROPOSAL: Looking For Life Elsewhere In the Universe
Although the possible existence of life on a planet circling a distant star is unlikely to have direct impact on life on Earth, scientists, as well as the general public continues to show interest in looking for signs of such life. An astrophysicist has developed a new mathematical theory on how to examine the numerous radio wave signals that arrive from space in order to determine whether they may have been produced by intelligent life. She seeks funding for the development and use of computer programs to test her theory.
Research Advisor Activity

Rank 1-9 with 9 being the least favorable to fund:

<table>
<thead>
<tr>
<th>Research Proposal</th>
<th>Individual Rank</th>
<th>Group Consensus</th>
<th>Class Consensus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of High Energy Rocket Fuel For Mission to Mars</td>
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Criteria = Extent to which you think the research:

- is important.
- may result in public benefit or harm.
- is necessary for the advancement of science.
- is likely to improve the country's economy.
- is likely to affect the environment.
- is important for the government to support.
- results may justify the cost.
Research Assistant Activity

Before scientists conduct original, experimental research, a review of published literature and available data must be conducted. Finding out what is currently known about the topic often helps the scientist refine their hypothesis.

- You are a research assistant to a scientist.
- You assume the responsibility of finding the most current information on your scientist’s area of study.
- You must communicate your findings to a panel of reviewers/scientists.
- Based on your findings and your recommendation, the panel of reviewers/scientists will decide whether the original research proposal has merit.

The problem, question, or hypothesis under consideration by your scientist is: _________________________________.

- Assemble and communicate findings about current information related to the proposed study.
- Make recommendations to a panel which must approve and fund the research study.
- Prepare a portfolio based on the proposed original research which includes:
  - Databases, Spreadsheets, Graphs of data,
  - Word processing to summarize findings,
  - Word processing to make a recommendation to the panel,
  - word processing to restate your recommended original, experimental research,
  - Multimedia presentation for panel of reviewers to summarize findings,
  - Multimedia presentation to make a recommendation to the panel,
  - Use of telecommunication to access current information, and
  - Societal impact/ethical issues related to the proposed research

- Connections to technology:
  - Will this research “create” new technologies?
  - Is it dependent on existing or to be developed technologies?
  - What are the risks? What are the benefits?

- Hold a mock research review panel that can only approve and fund a few projects.
- Have the panel make recommendations. Have the class debate the merit of each proposal and reach consensus on a limited number to “fund”.

Fall, 2005
Develop rubrics with student to provide standards for the portfolio and presentation.

Technological Design Strategy — Science Olympiad

Cooperation + Competition + Basic Science + Inquiry Science + Technological Design + Parental Involvement + Fun...
—SCIENCE OLYMPIAD

2006 Division B Competition

Biology
Disease Detective (7th, Goals 4 & 5)
Don’t Bug Me (all, Goal 1)
Heredit (7th, Goal 5)
Science of Fitness (7th, Goal 4)
Water Quality (8th, Goals 3 & 4)
Chemistry
Can’t Judge a Powder by It’s Color (8th, Goal 4)
Food Chemistry (8th, Goal 4)

Earth Science
Dynamic Planet: Glaciation (8th, Goal 5)
Meteorology: Climate (7th, Goal 3)
Reach for the Stars: Solar System (6th, Goal 5)
Road Scholar (all, Goal 1)
Rocks & Minerals (6th, Goal 3)

Nature of Science
Awesome Aquifer (8th, Goal 3)
Compute This (all, Goals 1 & 2)
Experimental Design (all grades, Goal 1)
Mystery Architecture (all grades, Goal 2)

Physics
Physical Science Lab: Balloon Race (all grades, Goal 1)
Sounds of Music (6th, Goal 6)
Storm the Castle (all, Goal 2)

Technology
Bottle Rocket (7th, Goal 6)
Bridge Building (all, Goal 2)
Mission Possible (all, Goals 1 & 2)
Wheeled Vehicle (7th, Goal 6)

SEE WEBSITE FOR ANNUAL UPDATES: www.tx.ncsu.edu/science_olympiad/ (an underscore “_” after “science”)
Technological Design Strategy — Science Olympiad

Science Olympiad Event Descriptions

Awesome Aquifer — Students will design and build a model aquifer that will allow a team to demonstrate and explain groundwater concepts.

Bottle Rocket — Participants will design, construct and test rockets made from plastic soft drink bottles, to remain aloft for a maximum period of time.

Bridge Building — Given certain parameters of length, width, height and material, each team is to design, build and test the lightest bridge to carry a maximum standard load.

Can't Judge a Powder — The characteristics of various powders will be identified.

Compute This — Teams are presented with a problem that requires quantitative data capture from the public Internet and the electronic organization and presentation of data in a graphical format.

Dynamic Planet — Teams will work at stations that display a variety of Earth Science materials and questions related to glaciers and oceans.

Experimental Design — Given a set of unknown objects and materials, teams will design, conduct, analyze and write-up an experiment.

Forestry — Students will demonstrate knowledge of taxonomic keys, habitats, life history and the geographic distribution of forests.

Fossils — Students will identify, describe and classify various fossil specimens.

Meteorology — Students will view charts, graphs, pictures, drawings and data to help them answer questions related to meteorology.

Mission Possible — Teams will design and build a “Rube Goldberg-like” device, which uses a series of different simple machines to accomplish a specific task within an optimal amount of time.

Naked Egg Drop — Teams construct (on-site) a package that will be used to successfully catch and protect an egg from breaking.

Process Skills for Life Science — Students answer a series of questions, mainly focusing on genetics, that are designed to test life-science lab skills such as measurement, observation and interpretation.
Technological Design Strategy — Science Olympiad

Science Olympiad Event Descriptions

Reach for the Stars – Teams identify constellations and solve astronomy problems/questions.

Road Scholar – Students will use a variety of road and topographic maps to accurately interpret and explain various surface features of the Earth.

Robo-Billiards – Teams will design and build a robot capable of performing certain tasks within a specified period of time.

Science Crime Busters – This is a forensics-type event where students correctly identify and interpret liquids, solids, other materials and evidence in a crime scenario.

Science of Fitness – Students will be tested on their knowledge of human fitness concepts.

Sounds of Music – A team will build musical instruments, describe the scientific principles behind their operation and perform a musical selection using the instruments that were constructed.

Storm the Castle – Teams will design, construct, calibrate and operate a device capable of launching a projectile as far and as accurately as possible using only the energy of falling counterweights.

Water Quality – Students will demonstrate an understanding of aquatic ecology, water resource management, water treatment practices and aquatic chemical processes.

Wright Stuff – Students will design and build a propeller driven aerodynamic device for the greatest time aloft.

Write It/Do It – A technical writing exercise where students write a description of a contraption and other students attempt to recreate it using materials and the written description.
Technological Design Strategy — Science Olympiad

Correlation to the North Carolina State Science Standards

6th Grade Goals and Objectives addressed by the event

Awesome Aquifer 3.08
Bottle Rocket 5.04, 1.03, 1.01, 1.04 – 1.06, 2.03
Bridge Building  Goal 2
Can’t Judge a Powder 1.05
Compute This 1.09
Dynamic Planet 3.01 – 3.04, 3.06 – 3.07, 1.05
Forestry 4.01 – 4.05, 7.01 – 7.06, 1.05
Fossils 1.05
Mission Possible 1.04 – 1.06, 1.01, 2.03
Process Skills-Life Science 3.08, 4.01 – 4.05, 7.01 – 7.06, 1.04 – 1.06, 1.01, 2.03
Reach for the Stars 5.01 – 5.03, 5.05
Road Scholar 3.01 – 3.02, 3.06, 1.05
Robo-Billiards 2.03, 1.01, 1.03 – 1.06
Science Crime Busters 1.03, 1.05
Science of Fitness 3.08
Sounds of Music 6.03, 1.04 – 1.06
Storm the Castle 1.01, 1.04 – 1.06, 2.03
Water Quality 3.08, 4.01 – 4.04, 1.05
Wright Stuff 1.01, 1.04 – 1.06, 2.03
Experimental Design 1.01 – 1.02, 1.04 – 1.08
Naked Egg Drop 1.01 – 1.02, 1.04 – 1.08
Write It/Do It  Stresses the use of communication skills to explain how an object is designed.
Technological Design Strategy—Science Olympiad

Correlation to the North Carolina State Science Standards

7th Grade Goals and Objectives addressed by the event

Awesome Aquifer 3.03 – 3.04
Bottle Rocket 6.03 – 6.06, 1.04 – 1.06, 1.01, 2.03
Bridge Building Goal 2
Can’t Judge a Powder 1.05
Compute This 1.09
Dynamic Planet 1.05
Forestry 3.03 – 3.04, 1.05
Fossils 1.05
Meteorology 3.01 – 3.06
Mission Possible 6.01 – 6.06, 1.01, 1.04 – 1.06, 2.03
Process Skills-Life Science 3.03 – 3.04, 4.01 – 4.08, 5.01 – 5.06
Road Scholar 1.05
Robo-Billard 6.01 – 6.06, 1.01, 1.03 – 1.06
Science Crime Busters 1.05
Science of Fitness 4.01 – 4.07, 4.08
Storm the Castle 6.03 – 6.06, 1.01, 1.04 – 1.06, 2.03
Water Quality 1.05
Wright Stuff 6.03 – 6.06, 1.01, 1.04 – 1.06, 2.03
Experimental Design 1.01 – 1.02, 1.04 – 1.08
Naked Egg Drop 1.01 – 1.02, 1.04 – 1.08
Write It/Do It Stress the use of communication skills to explain how an object is designed.
Technological Design Strategy-Science Olympiad

Correlation to the North Carolina State Science Standards

8th Grade Goals and Objectives addressed by the event

Awesome Aquifer 3.01, 3.03, 3.05 – 3.08
Bottle Rocket 1.04 – 1.06, 1.01, 2.03
Can’t Judge a Powder 4.01 – 4.02, 4.04 – 4.05, 4.08, 4.10
Compute This 1.09
Dynamic Planet 3.01 – 3.08, 5.01 – 5.05, 1.05
Forestry 1.05
Fossils 5.01 – 5.05, 1.05
Meteorology 5.01, 5.03, 5.04 – 5.05
Mission Possible 1.01, 1.04 –1.06, 2.03
Process Skills-Life Science 3.04 – 3.08, 6.01 – 6.04, 7.01 – 7.05, 1.01, 1.04 –1.06, 2.03
Road Scholar 5.04 – 5.05, 1.05
Robo-Billiards 1.01, 1.03 – 1.06
Science Crime Busters 4.01 – 4.10, 1.05
Storm the Castle 1.01, 1.04 – 1.06, 2.03
Water Quality 3.03 – 3.08, 1.05
Wright Stuff 1.01, 1.04 – 1.06, 2.03
Experimental Design 1.01 – 1.02, 1.04 – 1.08
Naked Egg Drop 1.01 – 1.02, 1.04 – 1.08

Write It/Do It  Stresses the use of communication skills to explain how an object is designed.
Goals 1 and 2 should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

Science is...PUBLIC

- No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world.

- The ethics of science require that potential subjects be fully informed about the risks and benefits associated with the research and of their right to refuse to participate.

- Scientists are linked to other scientists worldwide.

- The global environment is affected by national policies and practices relating to energy use, waste disposal, ecological management, manufacturing, and population.

- Scientific teams are expected to seek out possible sources of bias in the design of their investigations and in their data analysis.

- There are often several different ways of making sense out of a body of existing information.

- Scientists conduct their studies in a variety of workplaces including offices, classrooms, laboratories, farms, factories, and natural field settings.

- Science disciplines share a common purpose and philosophy, and all are part of the scientific enterprise.

- Scientists can bring information, insights, and analytical skills to bear on matters of public concern.

- Funding influences the direction of science by virtue of the decisions that are made on which research to support.
Teacher Notes:
**Goals 1 and 2** should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

*Science is...PUBLIC*

**Students should be able to:**

- Use a variety of multimedia to capture, present, and share information.
- State their own criteria for what are satisfactory results and to discuss their findings in terms of their purposes.
- Locate information from a variety of sources and evaluate the information based upon its source.
- Question claims based on vague attributions or on statements made by people outside the area of their particular expertise.
- Be skeptical of results based on very small samples of data, biased samples, or samples for which there was no control sample.

| To develop science literacy, students should explore the natural world and develop explanations of it, by -experimenting-observing and describing-designing and building-debating with each other-doing projects and research-taking field trips-reading journals and non-fiction works-asking questions-offering explanations and -citing evidence. |
Goals 1 and 2 should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

Science is... TENTATIVE

- Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
- New ideas in science may spring from unexpected findings, and can lead to new investigations.
- New ideas in science are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly, through contributions from many investigators.
- In science, testing, revising, and occasionally discarding of theories, new and old, never ends.
- Often different explanations can be given for the same evidence.

Science is... REPLICABLE

- When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide.
- Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct.
- Accurate record-keeping, openness, and replication are essential for maintaining an investigator’s credibility with other scientists and society.
- Hypotheses are valuable, even if they turn out not to be true, if they lead to further investigations.

The nature of science is that it deals with the phenomena, systems and events of the natural world, and uses tools to investigate them—it is not just theoretical, and should not be taught without having real world contexts in front of students at all times.
Goals 1 and 2 should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

**Science is... HISTORIC**

- Some scientific knowledge is very old and yet is still applicable to day.
- Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.
- Technology has strongly influenced the course of history and continues to do so.
- Technology is largely responsible for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, and communications.
- Societies influence what aspects of technology are developed and how these are used.
- Progress in science and invention depends heavily on what else is happening in society.

**Science is... PROBABILISTIC**

- Science can sometimes be used to inform ethical decisions by identifying the likely consequences of particular actions but cannot be used to establish that some action is either moral or immoral.
- What people expect to observe often affects what they actually do observe. Strong beliefs about what should happen in particular circumstances can prevent them from detecting other results.
- Historical and literary approaches ought to be used to imagine what the future will bring and to reflect on people's limited ability to predict the future.
**Goals 1 and 2** should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

*Science is... PROBABILISTIC*

- The graphic display of numbers may help to show patterns such as trends, varying rates of change, gaps, or clusters. Such patterns sometimes can be used to make predictions about the phenomena being graphed.

- How probability is estimated depends on what is known about the situation. Estimates can be based on data from similar conditions in the past or on the assumption that all the possibilities are known.

- Probabilities are ratios and can be expressed in a variety of ways.

- The larger a well-chosen sample is, the more accurately it is likely to represent the whole.

- A sample can be unrepresentative of the whole.

- Events can be predicted in terms of being more or less likely, impossible, or certain.

- Reasoning by similarities can suggest ideas but can't prove them one way or the other.

- Sometimes people invent a general rule to explain how something works by summarizing observations.

- A single example can never prove that something is true, but sometimes a single example can prove that something is not true.

- Mathematical statements can be used to describe how one quantity changes when another changes.

- As one variable increases uniformly, the other may do one of the following: always keep the same proportion to the first, increase or decrease steadily, increase or decrease faster and faster, get closer and closer to some limiting value, reach some intermediate maximum or minimum, alternately increase and decrease indefinitely, increase or decrease in steps, or do something different from any of these.

- The scale chosen for a graph or drawing makes a big difference in how useful it is.
Teacher Notes:
Goals 1 and 2 should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

Science is... PROBABILISTIC

- Probabilities of outcomes in familiar situations can be estimated on the basis of history or the number of possible outcomes.
- Sources of any large disparity between an estimate and a calculated result should be examined.
- Possible effects of measurement errors on calculations must be considered.
- The way data are displayed can make a big difference in how they are interpreted.
- When calculations are made with measurements, a small error in the measurements may lead to a large error in the results.
- Scientists can help people understand the likely causes of events and estimate their possible effects.

Mathematics skills are important.

- Usually there is no one right way to solve a mathematical problem, different methods have different advantages and disadvantages.
- Using mathematics to solve a problem requires choosing what mathematics to use; probably making some simplifying assumptions, doing computations, estimates, or approximations, and/or checking to see whether the answer makes sense.
- Negative numbers allow subtraction of a bigger number from a smaller number, and are often used when something can be measured on either side of a reference point.
- Numbers can be written in different forms, depending on how they are being used.
- How fractions or decimals based on measured quantities should be written depends on how precise the measurements are and how precise an answer is needed.
- Graphs can show a variety of possible relationships between two variables.
Teacher Notes:
**Goals 1 and 2** should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

**Mathematic skills are important.**

- Mathematics, creativity, logic, and originality are all needed to improve technology.
- An equation containing a variable may be true for just one value of the variable.

**Students should be able to:**

- Use mathematics to gather, organize, present data and to structure convincing explanations.
- Make and interpret scale drawings
- Find the mean, mode, median and identify outliers of a set of data.
- Determine the appropriate unit to label an answer from the units of inputs to the calculation and be able to convert compound units.
- Distinguish between mistakes, such as faulty multiplication, and reasonable choices that turn out to be unsuccessful and can be reconsidered.
- Decide what degree of precision is adequate and use significant digits to reasonably reflect those of the inputs.
Goals 1 and 2 should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

*Science and Technology are connected.*

- Technological problems often create a demand for new scientific knowledge, and the technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research.
- The availability of new technology itself often sparks scientific advances.
- Different technological circumstances existed in the past.
- Technology cannot always provide successful solutions for problems or fulfill every human need.
- Models can be displayed on a computer and then modified to simulate what may happen.
- Models are often used to think about processes that happen too slowly, too quickly, on too small a scale to observe directly, that are too vast to be changed deliberately, or that are potentially dangerous.
- Different models can be used to represent the same thing. What kind of model to use and how complex it should be depends on the purpose.
- A system can include processes as well as things.
- Thinking about things as systems means looking for how every part relates to others.
- A system may be thought of as containing subsystems and as being a subsystem of a larger system.
Teacher Notes:
Goals 1 and 2 should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand that:

- Identify points in the production cycle where used materials can be collected, sorted, and reprocessed into usable materials.
- Reflect on the influences that their own consumption choices can have on what products are made and how they are packaged.
- Read instruments used to make direct measurements of length, volume, weight, elapsed time, rates, and temperature, and choose appropriate units for reporting various magnitudes.
- Address the challenges of efficiency studies, designing production tooling, engineering a production facility, maintaining quality-control standards, ad marketing a final product.
- Inspect, disassemble, and reassemble simple mechanical devices and describe what the various parts are for; estimate what the effect that making a change in one part of a system is likely to have on the system as a whole.
- Use computers to collect, store, and retrieve data, to help in data analysis, to communicate with others, to prepare tables and graphs, to present findings to others, to conduct research and to write summary reports.
- Use calculators and computers to store and retrieve information in topical, alphabetical, numerical, and key-word files, and create files of their own devising.
Teacher Notes:
Goals 1 and 2 should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

By the end of their middle school science experiences, students should understand:

Experimental Design

- Although there are no fixed steps that all scientists follow, scientific investigations usually involve:
  - the collection of relevant evidence;
  - the use of logical reasoning; and
  - the application of imagination in predicting, devising hypotheses and explanations to make sense of the collected evidence.

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.

- If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables.

- Current scientific knowledge and understanding guide scientific investigations.

- The constraints of science must be taken into account for design of scientific investigations and technological design.

- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.

- The appropriate use of technology to gather and interpret data enhances accuracy and allows for modeling of data, visual representation and analysis for quantifying of results.

- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models and theories.

- Scientists take steps to try and avoid bias when designing investigations and examining data.

A curriculum is more than just a listing of objectives matched to grade levels. It is a tool for moving along a student’s understanding from unit to unit and grade to grade.
**Goals 1 and 2** should be taught in conjunction with content. However, the following includes a listing of key basic ideas from Goals 1 and 2. These should always be considered when designing instruction.

**Students should be able to:**

- Think critically about evidence includes deciding what evidence should be used and accounting for anomalous data.
- Remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.
- Communicate experimental methods, follow instructions, describe observations, summarize results of other groups, and provide explanation based on evidence.

“When we try to pick out anything by itself, we find it hitched to everything else in the universe.”

John Muir
Teacher Notes:
References


The collective teaching experiences of the Middle Grades Instructional Support Team and the numerous North Carolina science educators that piloted the materials provided the basis for suggested strategies contained in this document. Finding primary references for some of the ideas was felt to be unnecessary and/or impossible to attribute to one source, as what the idea or concept was a commonly held tenet in good teaching and had been around “forever”. If in reading this document you feel that a primary source has not been included that should have been cited, please forward the reference and link to the document so that we may give appropriate credit. Send information to Janet Bailey jbailey@dpi.state.nc.us or Clara Stallings cstallin@dpi.state.nc.us.
Teacher Notes: