Science Teacher's Toolkit, Grades K–8

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Exemplars Science Alignments

In an effort to assist teachers and administrators on the local level, *Exemplars* has aligned its science material to NGSS, state and national STEM standards.

To access our current product alignments please visit:
http://www.exemplars.com/resources/alignments

The alignments database can be searched by both standard and product.
This service is FREE!

We hope this feature will make implementation in your classrooms easier.

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Exemplars has helped schools and districts in 50 states and 30 foreign countries to meet the challenges of national, state and local standards.

What Is Exemplars?

Increasingly, schools, districts and states are adopting new standards and revising their science curriculums. Teachers, curriculum coordinators and administrators are grappling with how to incorporate them, along with new authentic assessments and instructional strategies into an already challenging classroom schedule.

We started *Exemplars* to respond to the many teachers we have worked with who have told us how badly they want to implement standards-based assessment and instruction in their classrooms and how challenging it is.

The goal of *Exemplars* is to provide performance assessment inquiry tasks, scoring rubrics, anchor papers and tips to make it more manageable for educators to implement new standards and this approach to assessment.

Exemplars began in 1993 with authentic assessment in mathematics for grades K–8 to help teachers, schools and districts implement the NCTM standards. It was created with the help of classroom teachers, drawn nationwide from model practitioners – teachers who have been through the process of setting standards, designing authentic inquiry tasks and using rubrics to assess student performance. It has helped schools and districts in 50 states and 30 foreign countries to meet the challenges of national, state and local standards. Response to this teacher-developed, classroom-tested model has been enthusiastic. It is viewed as "so user friendly and non-threatening" that teachers enjoy working with it.

In 1993, *Exemplars* added Mathematics 9–12, and in 1995 we added Science, K–8. RWR (Reading, Writing and Research in the Content Areas) was published for grades 5–8 in 1999. Our newest products include Developing Writers and Spanish *Exemplars*.

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Alignments to NGSS, state and national STEM standards can be viewed online at *http://www.exemplars.com/resources/alignments*

Science Exemplars

Science Exemplars is based on guidelines put forth by Benchmarks for Science Literacy (Project 2061 of the American Association for the Advancement of Science) and National Science Education Standards (National Research Council). Alignments to NGSS, state and national STEM standards can be viewed online at *http://www.exemplars.com/resources/alignments.*

Science Exemplars is focused on the big ideas of science beginning at the K–2 level and is concerned with content as well as process. (See the description of *Exemplars* Inquiry Tasks and Rubric on pages 6–18.)

Science Exemplars is a vehicle for improving assessment and instruction. It improves assessment by providing:

- Inquiry-based assessment tasks
- Rubrics that are aligned to state and national standards in science
- Anchor papers exemplifying four levels of science performance; Novice, Apprentice, Practitioner and Expert

It improves instruction by:

- Making standards clear to students
- Encouraging students to self-assess
- Giving students the opportunity to work as scientists on interesting investigations and inquiry tasks
- Providing teachers with support by relating each task to the big ideas of science; the context for the problem; interdisciplinary links; and possible solutions

Science Exemplars has been reviewed and approved by NSTA recommends® National Science Teachers Association

How Do People Use Exemplars?

People use *Exemplars* in many different ways.

- Teachers use *Exemplars* for both assessment and instruction, depending on the circumstances. The tasks in *Exemplars* are inquiry-based performance assessments. They can be used to help **teach** students skills and concepts and to **assess** students' understanding of skills and concepts.

  Exemplars include:
  - **Preassessments** – given at the beginning of a unit to assess what students already know
  - **Formative assessments** – given to inform instruction and assess how students are progressing
  - **Culminating or Summative assessments** – given at the end of the unit to assess student understanding

- *Exemplars* engaging inquiry tasks, rubrics and anchor papers make it an ideal vehicle for **professional development**.

- Administrators have found *Exemplars* to be a powerful way of reporting student performance based on national and state standards to their communities.

- Students use *Exemplars* to learn the practice of science and the process of self-assessment.

- Principals, curriculum coordinators, content area supervisors and staff developers have found *Exemplars* to be an effective way of helping teachers begin to understand standards and performance assessment.

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Many teachers will find unifying concepts a useful way to connect one lesson or unit to others throughout the year.

A Guide for Exemplars Science Inquiry Tasks

Exemplars tasks are designed for different developmental levels, and they have been grouped by grades K–2, 3–5 and 6–8. Each task is written with one of these developmental levels in mind. Often, for many tasks, adaptations (in materials, data collection procedures and tools, representations used, data analysis, etc.) can be made for students with more or less sophisticated levels of skills and understanding. Student work samples are benchmarked for the identified grade levels and the tasks as written.

Each task includes the following:

- **Inquiry Task and Essential Question to be Answered**
  Describes what science concepts this investigation explores and which science process skills are reinforced during the task. The Essential Question provides the lesson focus or the question students are trying to answer.

- **Big Ideas and Unifying Concepts**
  While no single lesson can address the "big ideas" of science, we have included some unifying concepts toward which particular tasks can help build an understanding in relation to other science lessons. Many teachers will find this a useful way to connect one lesson or unit to others throughout the year. Unifying concepts, identified by the national science standards, include:

  - Change-Constancy
  - Cause-Effect
  - Order and Organization
  - Models
  - Systems
  - Interdependence
  - Evolution and Equilibrium
  - Form and Function
  - Design
  - Patterns
  - Scale

- **Science Content**
  Science content areas that are addressed and assessed through *Exemplars* Science Inquiry Tasks are identified under five broad headings:
  - **Physical Science Concepts** – properties of matter, motion and forces, transfer and transformation of energy
  - **Life Science Concepts** – structure and function, reproduction and heredity, regulation and behavior, population and ecosystems, evolution, diversity and adaptations
  - **Design Technology** – use of tools, invention, design constraints and advantages, impact on human and other resources
  - **Science in Personal and Societal Perspectives** – personal health; populations, resources and environments; natural hazards; risks and benefits; and science, technology and society
  - **Earth Science** – earth systems; earth's history; solar system; and natural resource management

- **Time Required for the Task**
  Time is estimated and is based upon the teacher's field test.

- **Context**
  Describes what the students have already been doing in science to lay the groundwork for this activity and what prior knowledge and skills they might draw upon to accomplish the task.

- **What the Task Accomplishes**
  Describes how this investigation task will teach, reinforce, and assess the skills and knowledge identified in the corresponding science standards.

- **How the Student Will Investigate**
  Describes how students will be engaged during the task. Includes how the teacher might guide exploration, ask questions, and model skills needed for successful completion of the task.

- **Interdisciplinary Links and Extensions**
  Includes suggested topics and activities that can extend the learning from this activity to other content areas

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Children are natural inquirers, they still need to be taught the specific skills of inquiry so that they can begin to think and act as scientists do.

- **Teaching Tips and Guiding Questions**
  Includes ideas to guide the inquiry process during the lesson(s). While the children engage in exploration, suggested questions are provided to guide their thinking and lead them to the big ideas. Good questions ensure that students build understanding while they manipulate materials and record information. Questions should move from the specific (How is... different from...?) to the general (Can you state a "rule" about...? Do all materials... in the same way?)

- **Concepts to be Assessed**
  Identifies unifying concepts (big ideas) and science concepts to be assessed using the *Science Exemplars* Rubric criterion: Science Concepts and Related Content. This brief overview calls attention to what conceptual knowledge and scientific terminology students will demonstrate an understanding and use of in their work samples.
  For example:
    - Observing and explaining reactions of bending and not bending (cause-effect);
    - Observing and comparing physical properties of matter (comparing the weight, size, and flexibility of solids);
    - Classifying materials according to properties, etc.

- **Skills to be Developed**
  Identifies specific science process skills to be assessed using the *Science Exemplars* Rubric (under the criteria: Scientific Procedures and Reasoning Strategies and Scientific Communication/Using Data). This brief overview calls attention to scientific skills students will demonstrate an understanding and use of in their work samples.
  For example: Observing, Predicting, Classifying, Recording, Communicating, Measuring, etc. needed to complete the task.

- **Links to Science (and other) Standards**
  Identifies connections to science (and mathematics) standards.
  For example:
    - *Scientific Method:* Students describe, predict, investigate and explain phenomena.
    - *Scientific Theory:* Students look for evidence that explains why things happen, and modify explanations when new observations are made.
    - *Physical Science – Properties of Matter:* Students describe and sort objects and materials according to observations of similarities, and differences of their physical properties (size, weight, color, shape, texture and flexibility).

- **Suggested Materials**
  Suggests any advanced preparation and materials needed for the inquiry task to be carried out successfully.

- **Possible Solutions**
  Describes possible student solutions – what they should demonstrate; the ways they should organize their data; and possible conclusions they could make.

- **Rubric and Anchor Papers**
  Describes what is required to achieve each level of performance for a particular task and annotated samples of student work for each of the four performance levels: Novice, Apprentice, Practitioner and Expert. Descriptions attempt to point to the distinctions to look for when using the *Science Exemplars* Rubric to assess different levels of student learning and understanding.

About Student Self-Assessment

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You can find copies of *Exemplars* rubrics on your CDs. Rubrics may also be downloaded from our web site at *http://www.exemplars.com/resources/rubrics*

As teachers begin to use the *Science Exemplars* Rubric (pgs. 14–15) to assess their students' work, we encourage them to teach their students how to assess their own progress and performance through student rubrics. These rubrics simplify the language of the teacher's rubric, so that students can understand the criteria and become more involved in monitoring their own progress, leading them to become more self-directed learners.

The **primary student version** (pg. 16) of the *Science Exemplars* Rubric uses "friendly" visual representations to help limited readers understand the criteria for performance. The language in the rubric describes (in a positive way) what is happening, rather than what is not happening. For example, the Novice level states that, "I did not use tools YET." This implies that it can and will happen and gives some credit for early efforts. Primary students can use this rubric when conferencing with the teacher and peers about their work as they progress through a task. It can also be used with parents when students take work home to share.

The **intermediate version** (pgs. 17–18) of the student rubric – in worksheet form is presented in a different format than the teacher's rubric. It provides the four criteria, a description of expectations for each criterion, and a space where students are asked to provide evidence that they have met each criterion. This rubric also provides the opportunity for students to customize the rubric for each different inquiry task by filling in the specific tools to be used, the vocabulary and terms that are important, etc. Rather than having students simply state that they have met the criteria, this rubric asks them to note where the **evidence** can be found. Some teachers have students color code each criterion (blue dot for Tools, red dot for Reasoning, etc.) or use a shape (star for Tools, triangle for Reasoning, etc.) and place that code in their lab reports/science journals. Other teachers ask that students write the page or place where the evidence can be found. This process has a double benefit: students spend time documenting their own evidence for meeting standards and teachers save time in looking for it, shifting the responsibility to the student. This rubric is also effective for parent and peer conferencing.

It has been our experience, that students at all grade levels can learn to self-assess, using both work samples from other students (peers and/or student work samples from *Exemplars*) and their own work. The key to student self-assessment is clear consistent criteria, written with descriptive rather than evaluative language, which is presented at an appropriate time during the learning process.

Introducing Rubrics

A rubric is an assessment guide that reflects content standards and performance standards. An assessment rubric tells us what is important, defines what work meets a standard, and allows us to distinguish between different levels of performance.

Students need to understand the rubric that is being used to assess their performance. Teachers often begin this understanding by developing rubrics with students that **do not** address science. Together, they develop rubrics around classroom management, playground behavior, homework, lunchroom behavior, following criteria with a substitute teacher, etc. Developing rubrics with students to assess the best chocolate chip cookie, sneaker, crayon, etc. is also an informative activity that helps students understand performance levels. After building a number of rubrics with students, a teacher can introduce the *Exemplars Science* rubric (pages 15–16). Since the students will have an understanding of what an assessment guide is, they will be ready to focus on the science criteria and performance levels of the rubric.

We have included a sample rubric (page 13) developed by a teacher which assesses lunchroom behavior. It is very important to have your students develop their own rubric first . Sharing, adjusting, or using the rubric on page 13 can be done after your students have experienced the process for themselves.

The rubrics on pages 52–55 can be used by individual teachers or teams of teachers assessing student work. In the left-hand column the teacher records the evidence they see in the student work that justifies placing the work at that particular level. In the right-hand column the teacher would record the action(s) that can be taken to help the student move to the next performance level.

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Assessment (and self-assessment) will become a positive experience if students begin to feel that they have control over correcting and revising work to meet standards.

Guidelines for Using Student Rubrics

- **A Picture is Worth a Thousand Words:** Introduce rubric criteria and descriptions with examples of student work or demonstrations of what performance might look like. Provide several possible ways to meet the standards if they do exist. Guide students to think through the assessment process, looking for evidence. You may choose to introduce one or two criteria at a time before moving on, or introduce all of them at once.
- **Practice Makes Perfect:** Provide opportunities for students to use rubrics to conference with peers, teachers and parents about their work and the work of others. Assessment (and self-assessment) will become a positive experience if students begin to feel that they have control over correcting and revising work to meet standards.
- **Be Open to Suggestions From Students:** The more students understand the criteria, the more they will offer suggestions for other assessments. Guide them to use descriptive rather than evaluative language (avoid words like good, nice, poor) that clearly states what is happening.
- **Be Consistent:** We suggest that you introduce clear criteria and post them in the room as a reminder throughout the year of what good inquiry-based science involves. Students should have their own copies of student rubrics to refer to, so they can track their progress in each criterion as part of their science portfolios for the year.

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What are the Benefits of Peer- and Self-Assessment?

- **Students internalize the criteria for high-quality work.**
  Students who see clear models of work that meet the standards and understand why the work meets the standards will begin to make comparisons between their performance and the *Exemplars* presented. As science inquiry tasks become more complex and open ended, it is essential that more than one model be provided to assure that students understand several possible ways to meet the standards.

- **Students understand the process of getting to the standard.**
  Rubrics should show students where they have been, where they are now, and where they need to be at the end of the task. Describing progressive levels of performance becomes a guide for the journey, rather than a blind walk though an assessment maze.

- **Teachers involve students in the monitoring process and shift some of the responsibility for documenting and justifying learning to the students.**
  Research has demonstrated that high-performing learners do the following:
    - self-monitor,
    - self-correct, and
    - use feedback from peers to guide their learning process.

  Student rubrics, written to identify the essence of the expected learning, can be an excellent vehicle for reflective thinking and peer conferencing.

- **Parents understand expectations and assessment criteria.**
  When students can articulate to their parents (before, during and at the end of the task), what the standards of performance are, a clear and positive message is received. Parents generally want to support their child's learning and feel helpless, sometimes, because they are unsure of what open-ended tasks are intended to teach. Student rubrics remove the educational jargon yet still describe meaningful learning. Many teachers find rubrics useful during parent conferences as they review science work samples.

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Students, teachers and parents all benefit from peer- and self-assessment.

- **Students understand that standards are "real"—achievable—and that exceeding the standard is both possible and desirable.**
  Traditionally, many "good students" have done only what has been asked of them. The *Science Exemplars* Rubrics define high-quality performance at the Practitioner level but also suggest that more learning is possible. Excellence is not quite as subjective as it has been in the past and students are encouraged to begin to define why their work exceeds the standards.

Lunchroom Rubric—Behavior

Criteria	Level 1	Level 2	Level 3
Waiting-in-Line	Outside voice Touching, pushing, shoving Frontsies/backsies	Inside voice Occasional holding spots for an individual or cuts in line	Stage whispers Stays in space Joins line at end as enters cafeteria
Table Manners	<u>Rude</u> Stealing seat Eating off other's plate Poking/grabbing Throwing food Singing Wandering off	<u>Family</u> Kind words Elbows allowed Using fingers Eating at spot but standing	<u>Restaurant</u> Using please, thank you, excuse me No elbows No singing Chews with mouth closed Using utensils Staying in seat
Noise Level	Outside voice	Inside voice	Quiet inside voice (just above a whisper called a "Stage whisper")
Dismissal Prep	Dirty table/floor No recycling	Mostly clean table Mostly clean floor Some recycling	Clean table Clean floor Correct recycling

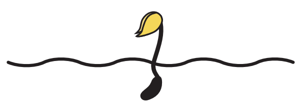
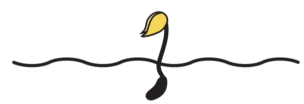
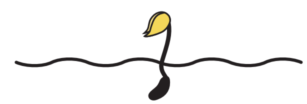
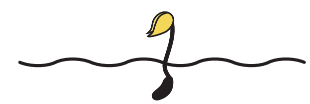
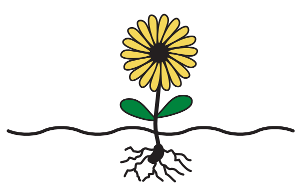
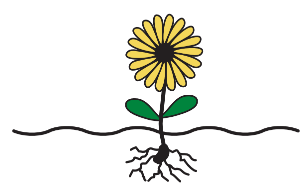
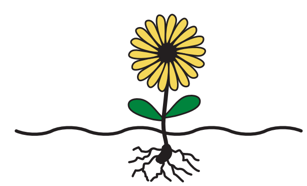
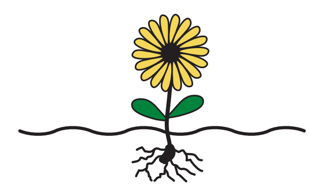
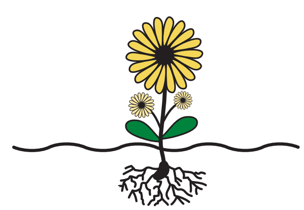
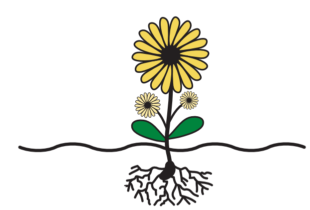
Exemplars® Science Rubric

	Scientific Tools and Technologies	Scientific Procedures and Reasoning Strategies	Scientific Communication/Using Data	Scientific Concepts and Related Content
Novice	• Did not use appropriate scientific tools or technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather data (via measuring and observing).	• No evidence of a strategy or procedure, or used a strategy that did not bring about successful completion of task/investigation. • No evidence of scientific reasoning used. • There were so many errors in the process of investigation that the task could not be completed.	• No explanation, or the explanation could not be understood, or was unrelated to the task/investigation. • Did not use, or inappropriately used scientific representations and notation (e.g. symbols, diagrams, graphs, tables, etc.). • No conclusion stated, or no data recorded.	• No use, or mostly inappropriate use, of scientific terminology. • No mention or inappropriate references to relevant scientific concepts, principles, or theories (big ideas). • No evidence of understanding observable characteristics and properties of objects, organisms, and/or materials used.
Apprentice	• Attempted to use appropriate tools and technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather data (via measuring and observing) but some information was inaccurate or incomplete.	• Used a strategy that was somewhat useful, leading to partial completion of the task/investigation. • Some evidence of scientific reasoning used. • Attempted but could not completely carry out testing a question, recording all data and stating conclusions.	• An incomplete explanation or explanation not clearly presented (e.g., out of sequence, missing step). • Attempted to use appropriate scientific representations and notations, but were incomplete (e.g., no labels on chart). • Conclusions not supported or were only partly supported by data.	• Used some relevant scientific terminology. • Minimal reference to relevant scientific concepts, principles, or theories (big ideas). • Some evidence of understanding observable characteristics and properties of objects, organisms, and/or materials used.

Exemplars® Science Rubric cont.

	Scientific Tools and Technologies	Scientific Procedures and Reasoning Strategies	Scientific Communication/Using Data	Scientific Concepts and Related Content
Practitioner	• Effectively used some appropriate tools and technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather and analyze data.	• Used a strategy that led to completion of the investigation/task. • Recorded all data. • Used effective scientific reasoning. • Framed or used testable questions, conducted experiment, and supported results	• A clear explanation was presented. • Effectively used scientific representations and notations to organize and display information. • Appropriately used data to support conclusions.	• Appropriately used scientific terminology. • Provided evidence of understanding of relevant scientific concepts, principles or theories (big ideas). • Evidence of understanding observable characteristics and properties of objects, organisms, and/or materials used.
Expert	• Accurately and proficiently used all appropriate tools and technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather and analyze data.	• Used a sophisticated strategy and revised strategy where appropriate to complete the task. • Employed refined and complex reasoning and demonstrated understanding of cause and effect. • Applied scientific method accurately: (framed testable questions, designed experiment, gathered and recorded data, analyzed data, and verified results).	• Provided clear, effective explanation detailing how the task was carried out. The reader does not need to infer how and why decisions were made. • Precisely and appropriately used multiple scientific representations and notations to organize and display information. • Interpretation of data supported conclusions, and raised new questions or was applied to new contexts. • Disagreements with data resolved when appropriate.	• Precisely and appropriately used scientific terminology. • Provided evidence of in depth, sophisticated understanding of relevant scientific concepts, principles or theories (big ideas). • Revised prior misconceptions when appropriate. • Observable characteristics and properties of objects, organisms, and/or materials used went beyond the task/investigation to make other connections or extend thinking.

Exemplars® Primary Science Rubric

Level	Science Tools	Reasoning Strategies	Communication	Science Concepts
Novice *Getting started* *No or little understanding*	I did not use science tools yet. I have no data. 	I mixed up my steps. 	I did not record or share my ideas. 	I do not get it yet. 
Apprentice *Almost* *Student has some understanding*	I tried to use some science tools. My data is started. 	I took steps. 	I started to record and share my ideas. 	I get some of it. 
Practitioner *Got it!* *Strong understanding* *Meets the standard*	I used science tools. My data is complete. 	I used organized steps. 	I recorded and shared my ideas. 	I get all of it. 
Expert *Wow, awesome!* *Exceptional understanding* *Exceeds the standard*	I made excellent use of all science tools. My data is complete. I can demonstrate. 	I used organized steps. I made more connections. 	I recorded and shared my ideas. I also recorded details and asked questions. 	I get all of it. I can teach it to a friend. My ideas shine! 

Intermediate Student Rubric

Criteria	What I Need To Do	Evidence of What I Did
Scientific communication/ Using Data	My data will be in a chart, table, graph, or And will be labeled. My data needs to prove my exploration. Someone can read my explanation and Understand it.	
Scientific concepts And related content	Terms I should use and understand: Things I need to be sure to observe or pay attention to: A "Big Idea" that might help me to connect my learning to other things I know or want to learn more about.	

Intermediate Student Rubric

Criteria	To Meet the Standard: What I need To Do	Evidence of What I Did
Scientific Tools and Technologies	These are the tools I need to use to collect data and do the task: I need to check for mistakes.	
Scientific Procedures and Reasoning Strategies	My hypothesis is: To complete the task I need to follow these steps: I need to record these dates:	

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When planning, teaching or assessing a science unit, it is important for teachers to consider the varying stages of development in children so that appropriate activities and assessments can be chosen.

Science Education and Developmental Stages of Children Ages 5–11

The information that follows describes the mental development of children between the ages of five and 11. It must be remembered that although children go through these stages in the same order, they do not go through them at the same rates. Some children achieve the later stages at an early age. Some children stay in the early stages for quite a time. All children experience an overlap of stages. Whereas a child may operate in a later stage in one area, he/she may operate in an earlier stage in another area. The stages illustrated conform to current research about children's thinking (learning). When planning, teaching or assessing a science unit, it is important for teachers to consider these stages so that developmentally appropriate activities and assessments are designed for students. Suggestions on how to do this are included along with descriptions of the various developmental levels of children.

Science Education and Developmental Stages of Children Grades K–1

Characteristics
Implications and Appropriate Learning Activities

Pre-operations Stage – Period of Representational and Pre-logical Thought Ages 5–7

- Reasoning is confined to appearance, or what the child sees happening
- Reasoning is not based on adult logic
- Learning is still largely perceptual
- Lacks the concepts of reversibility and conservation of matter
- Discovers that some things can stand for other things—the child's thinking is no longer tied to external actions and is now internalized
- This period is dominated by representational activity and a rapid development of spoken language
- Willingness to ask questions
- Willingness to handle both living and non-living materials
- Enjoyment in using all the senses for exploring and discriminating
- Willingness to collect material for observation or investigation
- Awareness of changes which take place as time passes
- Based on concrete experiences and the immediate environment
- Involve a variety of integrated experiences
- Short exploratory activities

Science Education and Developmental Stages of Children Grades 2–5

Characteristics
Implications and Appropriate Learning Activities

Concrete Operational Stage – Period of Concrete Logical Thought
Ages 7–11

- May include the characteristics of the younger age group
- Learns in concrete terms and obtains concrete information through manipulation of materials and equipment
- Can organize, test and express his/her results in words, pictures or number symbols
- Is capable of demonstrating logical thinking in relation to physical objects
- Is able to mentally hold two or more variables at a time when studying objects
- Has acquired the capacity of reversibility which allows him/her to mentally reverse an action that he/she had previously only done physically
- Is more sociocentric
- Is able to conserve certain properties of objects
- Is able to classify and order objects using one variable
- Is able to think of physically absent things that are based on vivid images of past experience—the child's thinking is restricted to concrete things rather than ideas
- Uses trial and error to draw conclusions about variables
- Desire to find out things for himself/herself
- Willingness to participate in group work
- Appreciation of the need to participate in group work.
- Awareness that there are various ways of testing out ideas and making observations
- Willingness to wait and to keep records in order to observe changes in things
- Enjoys exploring the variety of learning things in the environment
- Interested in discussing things
- Based on concrete experiences and a variety of hands-on materials
- Variety of integrated experiences
- May include cooperative groupings
- Units of study should have more depth than in K–1
- Journals or logs should be used to record information, observations, and to promote critical thinking
- Group discussion should be used to promote involvement and critical thinking
- Should include more discovery along with teacher lecture

Getting Started with Science Portfolios

Ideas for Tracking Performance Over Time

Science Exemplars is designed to make it possible for individual teachers to get started with excellent standards-based, performance assessment and instruction. Each science inquiry task leads teachers through the process of assessing their students, linking assessments to science (and sometimes mathematics) standards, and making sense of the results. The *Science Exemplars* CD makes it easy for teachers to find problems that fit with particular units of study. This section will focus on different aspects of how to successfully implement science portfolios in your classroom.

A portfolio is more than a container to hold and organize student work. Rather, it is a collection of work samples and evidence of learning over time. Without ways to manage and reflect upon what goes into the portfolio, even the best intentions for portfolios can be lost in the busy, day-to-day activity of a science classroom.

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A portfolio is more than a container to hold and organize student work. Rather, it is a collection of work samples and evidence of learning over time.

Portfolios should:

- Involve students in self- and peer-assessment;
- Provide multiple opportunities (and modes) for students to show evidence of learning and conceptual understanding;
- Guide students to reflect upon ways to improve performance; and
- Be based on some predetermined criteria for collecting that evidence.

Many teachers already use a variety of creative and effective ways to organize student work in science – science journals, learning logs, activity folders, etc. There is no reason to discontinue using anything that works for you now. What we will do is provide you with assessment guidelines; assessment tasks that can be used several times during the year; and management strategies, using the four broad criteria on the *Science Exemplars* Rubric (pgs. 14–15), to track and reflect upon progress and learning over time.

For an example of an assessment task used throughout the year to chart students' progress, please refer to the task *What Is Science?*. This lesson can be found on *The Best of Science Exemplars* CD.

Effective Classroom Assessment Practices and Guidelines

We suggest four broad guidelines to act as a framework for all of your classroom assessment practices, including the use of science portfolios. They are defined by areas on which to place more or less emphasis and incorporate best practices for science instruction.

1. **Clearly define and communicate expectations and standards for assessment.**

More of …	Less of …
• Focus on quality, excellence, and meaningful content • Clear, specific language describing desired learning outcomes, process and products • Clear links to national, state, and district standards for content learning and process skills • Activities are selected to help students demonstrate learning/meeting standards • Student and parent involvement in the assessment process as part of instruction and learning (e.g., before, during and after assignments) • Defining progressive developmental levels, with benchmarks, from Novice level to a level that exceeds the standard • Open posting of standards, benchmarks and assessment criteria	• Focus on perfection and "right" answers • Vague, evaluative, subjective language (e.g. words like: poor, good or assigning letter grades without consistency) • Activities are the means and the ends • Evaluation criteria developed solely by and known only by the teacher/text developer

2. Use formal and informal assessment strategies/methods to evaluate and ensure the continuous development of every learner and to communicate student progress knowledgeably.

More of …	Less of …
• Use of variety of modes and artifacts for communicating understanding to teachers, peers, and self • Collect work samples over time that demonstrate learning and conceptual understanding • Application of prior learning to new tasks/situations and real-world problems • Solving of student-generated problems/researchable questions to demonstrate learning and understanding • Products developed through cooperative learning groups with expectations for individual accountability • On-going assessment of all stages of the inquiry process including, thorough teacher observations and questioning; graphic organizers; peer feedback; student self-assessment of learning logs, etc. • Use of manipulative and appropriate scientific instruments and technologies to assess student skills and understanding in collecting and analyzing data	• Only verbal/written modes accepted • Use of a single assessment or a single type of assessment for an entire unit of study, usually at the end • Use of formulas and procedures out of context • Sole use of teacher/text-generated problems to be solved • Individual products and performances as sole means of evaluating learning • End-of-chapter tests, short answer tests, etc. as sole means for evaluating progress • Sole use of pencil and paper tests

3. **Use assessment strategies to involve learners in self-assessment activities.**

More of …	Less of …
• Teacher modeling of self-assessment; "thinking aloud" with students; using benchmark work to teach students to assess • Learners monitoring individual and group progress over time • Use of performance standards as the basis for peer conferencing and self-reflection activities • Student-centered language in assessment tools and practices; descriptive rather than subjective • Discourse between students and teachers regarding quality of work – before, during, and after assignments to promote continuous learning • Student input in defining standards and expectations and designing assessment tools • Encouragement for student understanding of strengths, needs and past performances to set personal learning goals	• Teacher providing all/the only feedback to students on perfomance/products • Lack of continuity between assessments of skills and concepts • Educational jargon in assessment tools • Non-specific feedback on progress (e.g., "nice work") which does not guide improvement or reflection • Adults setting all learning goals for students

4. Use a variety of assessment methods in order to continually monitor, reflect upon and adapt instructional practices to meet learner needs.

More of …	Less of …
• Student learning/ performance results drive instructional decisions • Use of on-going assessments to structure flexible groupings and mini lessons for those who need them • Use of embedded assessments as part of the instructional process • Use of conferencing with students to develop standards and identify needs	• Use of assessments solely for grading, ranking and reporting

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The *Science Exemplars* Rubric is designed as an analytic rubric that can be used both holistically and analytically. The annotated work samples that we provide with the tasks are scored **holistically**, that is to say that we use all four criteria to determine one level of performance: Novice, Apprentice, Practitioner or Expert.

Analytic and Holistic Scoring Rubrics: What is the Difference?

The *Science Exemplars* Rubric (pgs. 14–15) identifies four criteria for assessing student performance.

Dimensions of the rubric include:

- Scientific Tools and Technologies
- Scientific Procedures and Reasoning Strategies
- Scientific Communication
- Scientific Concepts and Related Science Content

Science Exemplars tasks focus on scientific investigation and inquiry. Students are encouraged to develop strategies to test their ideas; to use scientific tools of technology to gather and analyze data; to communicate their understanding by explaining, organizing data and/or drawing conclusions; to use scientific terms and facts appropriately; and to connect scientific terms and facts to the "big ideas" of science – science concepts. The annotated work samples that we provide with the tasks are scored **holistically**, that is to say that we use all four criteria to determine one level of performance: Novice, Apprentice, Practitioner or Expert.

Levels of Performance describe how students might typically demonstrate their understanding of the inquiry task or how they approach the investigation. It is possible for a student to score higher on one criterion than another while working through a complex task. This often causes teachers to question scoring a piece of work holistically.

The greatest advantages to holistic scoring are:

1. To be placed at a particular performance level, the student needs to demonstrate a minimum of mastery of all four criteria for that level; and
2. There is greater scoring reliability between different teachers using the same rubric to score the same student work.

The greatest disadvantage with holistic scoring is that students are sometimes unclear about how to improve their performance.

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At the end of the marking period, you, students and parents will have a map for identifying strengths and areas of need. Personal learning goals and meaningful practice can be developed once patterns have been identified. In time, peers should be able to conference in small groups to assist each other.

Analytic scoring takes each of the four criteria and assesses it as separate from the rest. For example, a student could be at a Novice level in use of tools, but at the Apprentice level for scientific procedures. Both students and teachers can use the descriptions in the analytic rubric, throughout the learning process, to determine how to improve performance in each of the four areas (Scientific Tools and Technologies, Scientific Procedures and Reasoning Strategies, Scientific Communication and Scientific Concepts and Related Science Content).

The advantages to scoring analytically are:

1. Teachers can focus instruction and assessment on one (or a few) criterion at a time;
2. Feedback to students is specific enough to assist students in improving performance; and
3. Patterns of strengths and weaknesses can be seen more easily.

The disadvantages might be:

1. It may take longer to assess each criterion separately if all are addressed in a complex task.

The *Science Exemplars* Rubric is designed as an analytic rubric that can be used both holistically and analytically. We suggest continuing to use the holistically-scored student work samples in *Science Exemplars* to inform instructional and assessment practices in your classroom. Because portfolios track progress over time, we suggest using a management tool that allows you to record student progress analytically. (We have included two versions on the following pages.)

Each student would have a page like one of these in his/her science portfolio. As tasks are completed, the date/topic (e.g., “9/14/98 – Insect Homes”) and the performance levels (Novice–Expert) are recorded. A brief conference is held with the student to fill in the “Areas to Work On” section. (Even an Expert can improve, so use this to stress excellence, not perfection.) “Areas to Work On” can include: more practice with a measuring device (Scientific Tools), targeting specific process skills (Scientific Procedures), providing models for better data organization (Scientific Communication), and/or using a science vocabulary guide when writing conclusions (Scientific Concepts). The student’s current performance should drive these indicators.

At the end of the marking period, you, students and parents will have a map for identifying strengths and areas of need. Personal learning goals and meaningful practice can be developed once patterns have been identified. In time, peers should be able to conference in small groups to assist each other.

Science Portfolio for ______________________________ Dates ______________________

For each science inquiry task, your performance will be recorded for the four criteria at the top. We will conference about ways to further improve the progress you are making.

Levels Achieved	Scientific Tools and Technologies	Scientific Procedures and Reasoning Strategies	Scientific Communication/ Using Data	Scientific Concepts and Related Content	Areas to Work on
Novice					
Apprentice					
Practitioner					
Expert					
Comments About Progress					

Science Portfolio for ______________________________ Dates ____________________

For each science inquiry task, your performance will be recorded for the four criteria at the top. We will conference about ways to further improve the progress you are making.

*NAPE N = Novice A = Apprentice P = Practitioner E = Expert

Task/Date	**Scientific Tools and Technologies**	**Scientific Procedures and Reasoning Strategies**	**Scientific Communication/ Using Data**	**Scientific Concepts and Related Content**	**Areas to Work on**
	N A P E	N A P E	N A P E	N A P E	
	N A P E	N A P E	N A P E	N A P E	
	N A P E	N A P E	N A P E	N A P E	
	N A P E	N A P E	N A P E	N A P E	
Comments About Progress					

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Inquiry science is student-centered and teacher-facilitated. It is in-depth and meaningful. Inquiry is the process of discovering, investigating and understanding the ideas and concepts of science.

The Process of Inquiry

What is Inquiry Science?

The tasks in *Science Exemplars* are inquiry based. For many teachers this term can be confusing. Does inquiry mean hands-on? Does it mean "doing" science activities? Or does it mean more than just those things? Yes, it does.

Inquiry science means that students are actively involved in doing hands-on science. By actively involved we mean that they are working collaboratively with others, posing questions, designing and carrying out investigations, solving problems, and reflecting on results and procedures. Inquiry science is hands-on, but it is also minds-on. Learning in an inquiry science classroom is seen as an active process in which students construct views of how the world works. During this process ideas and understandings are changed, modified and extended based upon the experiences the student has.

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The Process of Inquiry

Inquiry is a process. Many of the skills you will read about in this section will be familiar to you from your own school experiences. All of us have had to fill out "lab reports" at one time or another during middle and/or high school. For many of us, science was all about the lab reports and very little to do with the actual process of doing science. Inquiry science is much more than a lab report; it is a way of thinking, a way of learning and a way of exploring and investigating the world around us. The lab report can be a part of this, but it is not the sole purpose of inquiry.

Inquiry is not a linear process. It is cyclical in nature. As students explore, observe, question and investigate, new questions are formed, new observations are made and new investigations are begun. Through this process students' understanding deepens and misconceptions are uncovered and examined.

One misconception that teachers often have is that inquiry science comes naturally to children. While this is partially true: children are natural inquirers, they still need to be taught the specific skills of inquiry so that they can begin to think and act as scientists do. Yet at the same time we do not want to dampen their natural curiosity and wonder by making science overly "skill based." We also want to ensure that our students are learning the content outlined in our curriculums. In an inquiry science classroom, we can find a way to balance all these.

Preassessment

The process of inquiry should always begin with finding out what students already know. This **preassessment** is critical so that teachers can learn what students already know, what questions they have and what misconceptions they may hold. These will then help guide your unit of study. It is not necessary to teach an idea or concept if students already have an understanding of it. The questions that students have will help you plan what investigations are most worthwhile for students to conduct. You may also find that a number of students hold the same misconception, indicating that more time should be spent on those ideas. A more detailed explanation and some suggestions for preassessment are included in another section.

Exploration

Another critical aspect of inquiry is giving students time for **exploration**. When beginning a unit of study, students need ample time to explore the new materials and the ideas that these materials represent. During this exploration, many observations are made and many questions are posed. You will also find students beginning to conduct investigations as questions form in their minds. Their natural curiosity takes over and they want to find out what, and why and how. This exploration also allows students to become familiar with the materials and what they do. It is difficult to begin a unit with planned investigations if students are unfamiliar with materials and haven't had the opportunity to "play" with them. This "messing about" with materials can be hard for teachers. It means giving up some control and having a bit of chaos in your classroom. Start small, perhaps by only putting out some of the materials first and then slowly adding to them. Ask students to help you come up with some guidelines for these explorations and discuss safety and respect with them as well.

Observation

Observation is an important inquiry skill. These explorations can give you the opportunity to teach students how to be careful observers, how to use their senses to observe and how to record these observations. Again, balance is the key. Let students explore and observe without any other expectations except sharing informally with others through scientist's meetings or class/group discussions what they have explored and observed. Then, when appropriate, you can discuss observation and its role in science and why it's important to observe things carefully and record what was observed so that others can understand.

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The understanding and meaning that comes from students seeking answers to their own questions is the most powerful form of learning possible.

Scientist Meeting
The idea of a **scientist meeting** is an important piece of the process. It is an informal or formal gathering of students to share, discuss, debate, demonstrate, analyze and communicate what they are learning and to hear what others are learning. Scientist's meetings should happen on a regular basis and be an integral part of any science unit whether it's after an exploration, an observation, an investigation, a project or research. It can also take many shapes. As the teacher you can decide how to structure it depending upon your students, your topic and your teaching style.

Student Questions
From this exploration/observation as well as later investigations comes many questions. This is the heart of inquiry: **student questions**. Students have so many questions and our teaching should nurture these questions and allow students opportunities to find the answers to their questions. This can often be difficult because as teachers we have time constraints and curriculum to cover. But questioning is a skill that is used throughout our curriculum whether it's science, math, social studies, writing or reading. Therefore, having students raise questions and honoring those questions is never a waste of learning time. The understanding and meaning that comes from students seeking answers to their own questions is the most powerful form of learning possible. You may find that students raise questions whose answers fit nicely with your curriculum objectives. These questions that students raise can be embedded into the investigations you plan and/or be a part of independent research and investigations that students do on their own.

The questions that students raise can also be used for instruction. As students pose questions, record these somewhere for students to refer back to and to give answers to as they discover them. This is also a time when you can teach students how to raise testable questions. Not all questions that students raise are testable in the classroom. It is important for them to learn the types of questions and questioning words (who, what, where, when, how, why) and how they can answer each type of question.

Question might be classified as:

- **Classroom** (meaning we can test it here in the classroom or at home with the materials we have available),
- **Laboratory** (we could test these if we had the necessary equipment and materials, but maybe we could ask a scientist or even a high school science class to find out the answer for us), and
- **Research** (these questions can usually only be answered by looking it up in a book, an encyclopedia, or on the internet). Most if not all questions can be answered, you may not have time to find all the answers, but you will have given your students methods and tools for finding the answers.

Guided Inquiry
Another integral part of the inquiry process is **guided inquiry**. This instructional piece is critical to student learning and understanding. Guided inquiry can take many forms. It can be an opportunity to teach new skills, new concepts and new forms of communication. It can be an opportunity for students to practice skills, concepts and communication. And it can be an opportunity to ensure that your curriculum objectives are being taught as well as honoring student questions and giving them time to find the answers. Guided inquiry is the core of any science unit.

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The skills of inquiry include:

- Observing
- Questioning
- Predicting/hypothesizing
- Planning and conducting investigations
- Controlling variables
- Data collection, representation and analysis
- Drawing conclusions

All of these are skills that need to be taught. Students also need opportunities to practice these skills through meaningful investigations of questions and concepts and time to share their learning with others.

Guided inquiry can be conducted in a variety of ways. Here are just a few suggestions:

- Using questions posed by students, or questions from your curriculum or science program, have the whole class plan together ways to investigate the question. Discuss the components/skills of inquiry that need to be in place for investigation and then have students break into smaller groups to investigate. Come back as a whole group to share results and draw conclusions together.
- After exploring materials, have students share questions they have that they would like to investigate (remember to think about developing testable questions). As a whole group assist each group in planning their investigation. Once the smaller groups have investigated they can then share their results and conclusions with the whole class.
- As students begin to plan more of their own investigations, give them opportunities to share their plans before beginning, in order to receive feedback from you and/or the class. You can also have students use planning sheets to ensure that they have all the components in place.

- Select a skill that students seem to be struggling with, such as controlling variables. Find tasks/investigations that emphasize this skill and use these to teach the skill to students. After investigating, discuss how well the investigation went and how their results reflect their understanding of this skill.
- Choose investigations that emphasize specific concepts in your unit. Use these investigations to ensure that students are developing a deep understanding of the ideas. These investigations should also allow students to continue practicing the skills of inquiry.
- Drawing conclusions based upon data collected can be practiced not only through science investigations, but through math, reading and social studies. Provide many opportunities for students to collect different types of data and draw conclusions.
- Find tasks/investigations that allow you to teach a variety of ways to collect data. Discuss different representations (charts, tables, diagrams, graphs, etc.) with students. Ask students to think about representations that work best for different kinds of data. Practice these as a whole group, modeling different types, and then have students use these in their own investigations. This can also tie in with mathematical representation.
- Use samples of students' work from investigations to look at and discuss as a whole group. This is also an effective way to reinforce not only the skills being practiced but conceptual learning as well.

Student Directed Inquiry

Once students have had many guided inquiry experiences, they can begin to design and conduct their own investigations to answer their own questions. **Student directed inquiry** should be a part of every science unit. A rule of thumb is to give students this opportunity at least once during a unit of study. It usually is at the end of a unit, when students are ready and have a solid grasp of skills and concepts. Student directed inquiry can be used as a culminating task with students presenting their investigations more formally to the class. The major difference between guided inquiry and student directed inquiry is that students have the responsibility for all aspects of the investigation.

You may ask yourself, what about lectures and demonstrations? What if I have to use a program that my school purchased that isn't inquiry based? These are important questions. The key again is balance. You could use the scientist's meeting time for a "lecture" or to do a demonstration. Wait until students have first explored and investigated the topic and materials for themselves before introducing appropriate vocabulary or more complex ideas. You will find these "teachable moments" when students are ready for them.

Many schools already have wonderful programs in place for their science curriculum. The most important thing to remember is that no program can be truly inquiry based. It will always be missing the student-directed inquiry component. And many programs tend to be more cookbook in style, where students follow prescribed investigations to get certain results. If you are using such a program, there is much you can do to make it more inquiry based. The simplest thing to do is to allow students to make some of the decisions. For example, if an activity has a great question to investigate and all the steps are given for students to follow, give them only the question and have them plan the steps of the investigation for themselves. Think about some of the suggestions for guided inquiry mentioned above. Use these in conjunction with your program.

Above all, remember that inquiry-based science teaches our students to think. It teaches them that their questions and their ideas are important. After all, this is exactly what real scientists do.

Guiding Students to Design and Conduct Investigations

There are numerous investigations that teach and assess. Here are some sample questions to ask students as they work through their investigations.

(Students can also use these questions and examples as a guide to plan, design and carry out a fair test investigation. The teacher and/or peers can also use this guide to review each other's work and suggest ways to improve.)

Testable Questions

Can you answer this question only by experimenting?
(A Testable Question: Does a banana peel decay faster than an apple peel?)
(Not Testable: Why is the sky blue?)

- What are you curious about?
- What do you want to find out?
- What do you already know about this?
- What is your testable question?

Hypotheses and Making Predictions
What do you think will happen?

- What is your idea?
- What do you already know about this that makes you think so?
- Can you state your prediction to show what you think will happen or change? (When I do this ___________, I think that __________will be the result.)

Procedures
How will you test this? What materials will you need? What are the variables?

- What is your idea for an exploration? Write out each step so someone else could do it from your directions.
- What will you need? Try to be specific. Do not forget your tools for measuring.
- How will you be sure it is a fair test?
- What are the variables that will stay the same? What might change? What will you observe?

Collecting and Organizing Data
What actually happened?

- What did you see? Hear? Smell? Can you add details to your observations?
- What actually happened?
- What did you measure?
- What units of measure (minutes, inches, etc.) will you label in your data?
- Will your data be in a chart? Graph? How will you label the important headings?
- Are there important dates or times included with your data? How often did you record data?
- Can you make a drawing or drawings to clearly show and explain your results? What will be labeled?

Drawing Conclusions
What did you find out? What have you learned?

- Remember your prediction? Did you get the results you expected? Can you use examples from your data to support your results? Can you explain why this happened or extend your thinking about this now?
- Did anything go wrong along the way? Did you have to change your experiment along the way?
- Did anything surprise you?
- Do you have any new ideas or new questions?

✎ You can use *Exemplars* web site to search for science tasks that align with your states' standards. Visit *http://www.exemplars.com/resources/alignments*

Implementing Exemplars in the Classroom

When planning units we recommend using the backwards-design process as a means to assist the teacher with ensuring that units of study are aligned with local or national science standards. This process will also help the teacher understand the necessary scaffolding of science concepts and skills.

The process is as follows:

1. **Select Standards**. These are the standards that you will assess during the course of the unit. It is important to choose a balance of content and skill standards for the unit. It is also important to limit the number of standards you select to three-five total standards for a typical four week unit of study. Select standards that embrace important ideas and skills for the students at your grade level and for the topic you are teaching. If you have a standards-based curriculum use the objectives listed for your grade level.

2. **Build Essential Questions**. Essential questions address the big ideas, concepts, skills and themes of the unit. These questions shape the unit; focus and intrigue students on the issues or ideas at hand; are open ended and no one obvious right answer. These questions should be important and relevant to the students and allow for several standards if not all of the standards selected to be addressed. These questions should engage a wide range of knowledge, skills and resources and pose opportunities for culminating tasks or projects where students can demonstrate how they have grappled with the question.

3. **Design Culminating Tasks.** This final task or project should encompass and help assess each of the standards selected and should enable students to answer or demonstrate understanding of the answer to the essential question. The task should be multi-faceted, allow for multiple points of entry and be performance based. It should allow students to apply their skills and knowledge learned in meaningful and in-depth ways. *Exemplars* tasks that match your standards can be powerful culminating tasks.

4. **Develop Learning and Teaching Activities**. These activities and tasks should address the standards selected and guide student learning towards what they need to know and be able to do in order to achieve the standards. Select relevant *Exemplars* tasks that assist with teaching appropriate content, skills and/or strategies.

There are four major types of learning and teaching activities:

- **Introductory Activities** are used to preassess students' prior knowledge and to generate student interest in the unit of study. These activities tend to be interactive, exploratory and stimulating.

- **Instructional Activities** are used to provide opportunities for students to learn and demonstrate specific skills, knowledge and habits of mind. These are usually sequenced and scaffolded, tied to specific standards and objectives, interesting, engaging, in-depth, active and interactive and can also be used for formative assessment during the course of the unit to measure student progress and inform instruction.

- **Assessment Activities and the Culminating Activity** are used to assess both students' progress towards attainment of the standards and for summative purposes at the end of the unit. These activities usually involve some type of product or performance by the student.

* *All activities selected, both Exemplars tasks and other activities, should be based upon their utility in helping students learn and demonstrate the knowledge and skills identified in the standards selected. Activities should accommodate a range of learning styles and multiple intelligences and be developmentally appropriate. Activities should also have a purposeful and logical progression for both knowledge and skill attainment.*

5. **Create Student Products and Performances.** Consider what criteria you will use to assess student learning both before, during and after the unit. Use the *Exemplars Science* rubric to assess relevant knowledge, skills or problem-solving strategies as students work on and complete *Exemplars* science tasks. Collect and use examples of student work that demonstrates the criteria selected and the different levels of performance. Allow opportunities for students to self-assess using the rubric.

An Example of the Backwards Design Process

Standards:

National Science Standards Grades K–4:

Develop abilities necessary to do scientific inquiry

- Ask questions about objects, organisms, events in the environment
- Plan and conduct simple investigations
- Employ simple equipment and tools to gather data and extend the senses
- Use data to construct a reasonable explanation
- Communicate investigations and explanations

Develop an understanding of position and motion of objects

- The position of an object can be described by locating it relative to another object or the background.
- An object's motion can be described by tracing and measuring its position over time.
- The position and motion of objects can be changed by a force (push or pull). The size of the change is related to the strength of the push or pull.

Essential Question: How do objects move? What forces affect an object's motion?

Culminating Task:
Can You Design a Marble Mover? (Best of *Science Exemplars* CD, grades 3–5) In this task students are asked to consider inertia, gravity and friction to design a marble mover that will move a marble a certain distance. In order to do this task students will have had to have numerous opportunities to observe motion and investigate these major forces that affect motion. Students will also have needed to practice the skills of inquiry: questioning, predicting, designing and conducting an investigation, fair testing, collecting and recording data, analysis of that data and drawing conclusions. Students will then present their marble mover to the class. Students will use the *Science Exemplars* Rubric to self-assess their work.

Learning and Teaching Activities for Position And Motion Of Objects*

**This section includes both K–2 and 3–5 tasks that focus on position and motion of objects. These investigations can be found on the Exemplars* Best of Science, K–5 *CD. If you are teaching upper elementary students you can easily use the K–2 tasks by giving students more choices in the materials being used, the procedures being followed, or the amount of support you give for recording their investigations. Likewise, for primary grade teachers, you can give students more support with the 3–5 tasks.*

- **Introductory Activities:** These might include a K–W–L chart, exploration and observation of things that move around the classroom as well as any other motion materials that are available. Refer to the K–2 tasks *What Can Motion Be?* and *Observing Motion: What are some different ways that things can move?*. These activities help students to begin to think about and explore the different ways that things move. It is also a time when students begin to form questions about motion.

- **Instructional Activities:** These will include more focused activities around the skills and concepts. It is important to build a foundation of knowledge so that students can understand first that objects can move in different ways, then progress to understanding that there are forces that can change an object's motion and its position. Each of the tasks below provides these guided inquiry experiences. The tasks that are listed are scaffolded and help students to answer the essential questions.

- **Assessment Activities:**
  During the course of the unit select two or three of the tasks on the following page to use for formative assessment purposes. These will help inform instruction by providing information about how students are progressing towards the standards and about their understanding of the skills and concepts. This can also be an opportunity to teach students how to self-assess.

Task	Concepts and Skills
How Do Things Move? (Grades K–2)	• Observing objects in motion • Applying forces to objects (push and pull) • Questioning • Predicting • Recording data • Drawing conclusions • Communicating
What Can I Learn From Toys that Move? (Grades K–2)	• Observing objects in motion • Applying forces to objects (push and pull) • Predicting • Conducting simple investigations • Recording data • Drawing conclusions • Communicating
Will it Roll or Slide (Grades K–2)	• Observing objects in motion • Applying forces to objects (push, pull, gravity, friction) • Predicting • Conducting simple investigations • Controlling variables • Recording data • Drawing conclusions • Communicating
Wind up Toys, Part 1 and 2 (Grades K–2)	• Observing objects in motion • Applying forces to objects (push and pull) • Planning and conducting simple investigations • Controlling variables • Recording data • Drawing conclusions • Communicating
How Do Ramps Work? (Grades K–2)	• Observing objects in motion • Applying forces to objects (push, pull, gravity, friction, inertia) • Predicting • Conducting simple investigations • Controlling variables • Recording data • Drawing conclusions • Communicating

Which Ball Goes the Farthest? (Grades K–2)	• Observing objects in motion • Applying forces to objects (push, pull, gravity, friction, inertia) • Investigate the idea of mass and motion • Predicting • Planning and conducting simple investigations • Controlling variables • Recording data • Drawing conclusions • Communicating
How Does Push Affect Distance? (Grades K–2)	• Observing objects in motion • Applying forces to objects (push, pull, gravity, and inertia) • Predicting • Planning and conducting simple investigations • Controlling Variables • Recording data • Drawing Conclusions • Communicating
Rolling and Sliding: How Does Surface Affect Moving Objects? (Grades K–2)	• Observing objects in motion • Applying forces to objects (push, pull, and friction) • Predicting • Planning and conducting simple investigations • Controlling Variables • Recording data • Drawing Conclusions • Communicating
How Far Can you Make a Toy Car Go? (Grades 3–5)	• Observing objects in motion • Applying forces to objects (push, pull, gravity, inertia and friction) • Investigating the idea of mass and motion • Predicting • Planning and conducting simple investigations • Controlling Variables • Recording data • Drawing Conclusions • Communicating

How Does a Sail Affect the Motion of a Vehicle? (Grades 3–5)	• Observing objects in motion • Applying forces to objects (push, pull, inertia and friction) • Predicting • Planning and conducting simple investigations • Controlling Variables • Recording data • Drawing Conclusions • Communicating
Weight's Affect on Pendulum Motion (Grades 3–5)	• Observing objects in motion • Applying forces to objects (push, pull, gravity, inertia and friction) • Investigating the idea of weight and motion • Predicting • Planning and conducting simple investigations • Controlling variables • Recording data • Drawing conclusions • Communicating
Questions About Inertia (Grades 3–5)	• Observing objects in motion • Applying forces to objects (push, pull, gravity, inertia and friction) • Investigating the idea of mass and motion • Questioning • Predicting • Planning and conducting simple investigations • Controlling variables • Recording data • Drawing conclusions • Communicating

After completing these tasks, students can then pose their own question about motion and forces to plan and conduct an investigation for.

You may have other favorite investigations to include. Think about where they should go in terms of scaffolding: what concepts do they help the student understand? What skills do they teach, practice or reinforce?

Vocabulary

Friction: Resistance to motion of surfaces that touch.

Inertia: Newton's 1st law of motion that states an object at rest tends to stay at rest and an object in motion tends to stay in motion unless they are acted upon by an unbalanced force.

Force: A push or a pull.

Gravity: A force that pulls things down towards the earth.

Mass: The amount of matter or stuff that something is made of

Products and Performances:
Student products and performances will include all work done from these investigations whether it is a recording sheet, a journal entry, a project or research.

The rubrics on the following pages (52–55) can be used by individual teachers or teams of teachers assessing student work. In the left-hand column the teacher records the evidence they see in the student work that justifies placing the work at that particular level. In the right-hand column the teacher would record the action(s) that can be taken to help the student move to the next performance level.

Exemplars Science Rubric

Scientific Tools and Technologies

Evidence	Action

Novice	Apprentice	Practitioner	Expert
• Did not use appropriate scientific tools or technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather data (via measuring and observing).	• Attempted to use appropriate tools and technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather data (via measuring and observing) but some information was inaccurate or incomplete.	• Effectively used some appropriate tools and technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather and analyze data.	• Accurately and proficiently used all appropriate tools and technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather and analyze data.

Exemplars Science Rubric

Scientific Procedures and Reasoning Strategies

Evidence	Action

Novice	Apprentice	Practitioner	Expert
• No evidence of a strategy or procedure, or used a strategy that did not bring about successful completion of task/investigation. • No evidence of scientific reasoning used. • There were so many errors in the process of investigation that the task could not be completed.	• Used a strategy that was somewhat useful, leading to partial completion of task/investigation. • Some evidence of scientific reasoning used. • Attempted but could not completely carry out testing a question, recording all data and stating conclusions.	• Used a strategy that led to completion of the investigation/task. • Recorded all data. • Used effective scientific reasoning. • Framed or used testable questions, conducted experiment, and supported results.	• Used a sophisticated strategy and revised strategy where appropriate to complete the task. • Employed refined and complex reasoning and demonstrated understanding of cause and effect. • Applied scientific method accurately: (framed testable questions, designed experiment, gathered and recorded data, analyzed data, and verified results).

Exemplars Science Rubric

Scientific Communications/Using Data

Evidence	Action

Novice	Apprentice	Practitioner	Expert
• No explanation, or the explanation could not be understood, or was unrelated to the task/investigation. • Did not use, or inappropriately used, scientific representations and notations (e.g. symbols, diagrams, graphs, tables, etc). • No conclusion stated, or no data recorded.	• An incomplete explanation or explanation not clearly presented (e.g. out of sequence, missing step). • Attempted to use appropriate scientific representations and notations, but were incomplete (e.g. no labels on chart). • Conclusions not supported or were only partly supported by data.	• A clear explanation was presented. • Effectively used scientific representations and notations to organize and display information. • Appropriately used data to support conclusions.	• Provided clear, effective explanations detailing how the task was carried out. The reader does not have to infer how and why decisions were made. • Precisely and appropriately used multiple scientific representations and notations to organize and display information. • Interpretation of data supported conclusions, and raised new questions or was applied to new contexts. • Disagreements with data resolved when appropriate.

Exemplars Science Rubric

Scientific Concepts and Content

Evidence	Action

Novice	Apprentice	Practitioner	Expert
• No use, or mostly inappropriate use, of scientific terminology. • No mention or inappropriate references to relevant scientific concepts, principles, or theories (big ideas). • No evidence of understanding observable characteristics and properties of objects, organisms, and/or materials used.	• Used some relevant scientific terminology. • Minimal references to relevant scientific concepts, principles, or theories (big ideas). • Some evidence of understanding observable characteristics and properties of objects, organisms, and/or materials used.	• Appropriately used scientific terminology. • Provided evidence of understanding of relevant scientific concepts, principles or theories (big ideas). • Evidence of understanding observable characteristics and properties of objects, organisms and/or materials used.	• Precisely and appropriately used scientific terminology. • Provided evidence of in depth, sophisticated understanding of relevant scientific concepts, principles or theories (big ideas). • Revised prior misconceptions when appropriate. • Observable characteristics and properties of objects, organisms, and/or materials used went beyond the task/investigation to make other connections or extend thinking.