# Language Arts

## What Is The Purpose Of Language Arts?

The ability to communicate impacts a person's achievement in all academic areas of school and throughout life beyond school. As individuals read, write, speak, listen, and observe, the ability to communicate grows increasingly more sophisticated and refined. Language arts instruction guides students in becoming literate citizens, capable of reasoning and problem solving.

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*Learning and communication are not linear processes.*

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## A Learning Spiral

The language arts program may be seen as a spiral through which students at every age practice similar experiences with increasing sophistication and maturity. Process components are introduced at the appropriate developmental level and then are reinforced, strengthened, and refined. Thus, language is learned through frequent practice, making active involvement an essential component of learning.

This spiraling process represents language acquisition as complex and developmental. These capacities are acquired at different rates, in different ways, and by building on prior knowledge.

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*In Mr. Lewis's primary class, a group of students have just listened to "The Gingerbread Man." As they talk about the story, they decide they would like to bake their own gingerbread people. . .*

*During reading workshop in Ms. Edward's 8th grade class, Jean chose a new book and started to read. She can hardly wait to talk with her best friend and share what she has read. . .*

*Ms. Brown's juniors have just read in the newspaper that graduation requirements may change. They generate a list of their own recommendations and compare them to the actual proposal. Strong opinions abound and they want to be involved. Plans include speaking at the public hearings, writing letters. . .*

*Listening, speaking, reading, and writing are occurring in all three classrooms. The age levels are different; the materials are different; the teaching strategies are different. The academic expectations are the same -- the use of language for real, worthwhile purposes.*

## A Learning Whole

Reading, writing, speaking, listening, and observing are not separate subject offerings. They are parts of an interdependent whole. Instruction must mirror reality and make connections among these highly interrelated processes. Language development should occur in rich, real-world contexts with multiple opportunities to explore, understand, and share.

## A Learning Standard

The International Reading Association, the National Council of Teachers of English, and the Center for the Study of Reading have united efforts to develop national standards for reading, language arts, and English in the United States. These standards will guide teachers as they help students develop literacy, language abilities, critical thinking skills, and creative problem-solving strategies. Scheduled for completion in 1995, the standards will include a framework for teaching and learning with vignettes of classroom practice.

## A Learning Tool

Communication is a tool for learning and demonstrating knowledge across the curriculum. It is critical that the academic expectations traditionally associated with language arts programs be part of all disciplines. The academic expectations for language arts–reading, listening, observing, writing, and speaking–are included in Learning Goal 1 to emphasize the application of communication skills in situations similar to real life.

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*Only through learning to speak, listen, read, and write imaginatively and skillfully can any of us achieve personal fulfillment and the literacy necessary to participate . . . in a democratic society.*

**Janet Emig, Chair**
**Standards Project for English Language Arts**

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# Science

*Science is built of facts, just as a house is built of bricks,*
*but a collection of facts cannot be called a science*
*any more than a pile of bricks can be called a house.*

**Henri Poincare**

Science is a way of knowing. It is a way of solving problems. It is a way of organizing information, seeing relationships, understanding how things work, keeping a proper perpective, recognizing the consistency of the universe, and observing change.

The challenge is not to specify content used to address the academic expectations, but rather to determine a different way of looking at this content. There is no lack of topics to be used in science classes. There is, however, a new responsibility for teachers of science to reorganize their instruction.

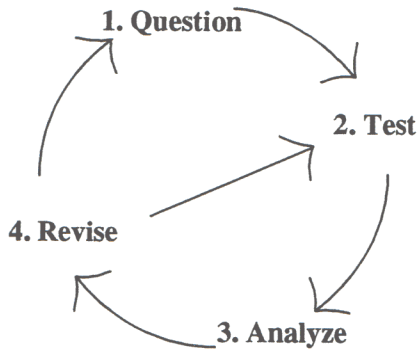
In the past, emphasis has been on the "What" rather than the "How"—content rather than process. Teaching the "What" of science is important, but students need to use the "How" as well. There must be an integration of the two, along with the development of a positive attitude toward science, in order to keep a balance. Care must be exercised not to substitute one for the other as a description of science.

## The Earth Day Project

*Both Ms. Brown's and Mr. Rose's science classes wanted to work together on a project for Earth Day, but they wanted it to last longer than just one day. They also wanted to do something out of the ordinary. After much discussion, someone suggested that the students do a study of water quality in their school district. The local public television station had a telecommunications network they could hook into for collecting data from students at the other end of the county 45 miles away. They looked at maps to locate water sources, learned how to do water tests, and recorded their data in a computer database. When they started to analyze the data, they found some discrepancies, so another team retested the water at those sources to verify the data. Finally, they made some recommendations to the water district council members about ways to improve the water in their area. Even though the original idea was to collect the information for the month before Earth Day, the classes decided to extend the project over a longer period of time. The students came back to Ms. Brown's and Mr. Rose's classes the next year to teach the procedures to the new students.*

# Methods of Science

Scientists systematically search for information that either supports or refutes their "best guess." This **method of inquiry** can be used by students of all ages or abilities. Memorizing "the scientific method" does not ensure that students can do science or understand the process. Hands-on experiences used to develop process skills and understand concepts are more apt to help students apply their knowledge to real-life situations and improve their attitudes toward science. These systematic procedures do not guarantee successful experiments; on the contrary, much has been learned in scientific study by analyzing "failed" experiments. The purpose of investigations is to discover what happens and to generate more questions, not to make the data fit the hypothesis or to change the hypothesis to match the data.




What is the inquiry method? One model follows:

1. **Question:** Why, how, and when does something happen? What are cause and effect? *(Hypothesize, predict)*
2. **Test:** Observe; collect, display, and interpret data; measure; identify and control variables. *(Experimental design; use of models, scale)*
3. **Analyze:** Predict, infer, draw reasonable conclusions.
4. **Revise:** Verify results, hypothesize. *(Redesign)*
5. **Test, analyze, revise:** Identify and control new variables; retest.

Analyzing the results of an investigation or experiment may generate new questions which could be the basis for further study.

# Themes of Science

The major themes of science as identified in the academic expectations can be organized in a variety of ways throughout the student's educational experience. At all levels, Primary through grade 12, the disciplines of science provide topics for any of the themes. The following paragraphs offer one possible configuration of organization. No part of this model is required to be implemented; it is merely a suggestion.

The process skills identified in the Nature of Scientific Activity are the means to an understanding of the themes. Extensive development and sophisticated application of process, thinking, and manipulative skills are expected of all students. The application of these skills should be evidenced in all science disciplines, as well as in interdisciplinary studies such as environmental education.

## Elementary

Fostering and guiding the natural inquisitiveness of children's early years lay the foundation for success in many later endeavors. As students gain experiences using the process skills, they progress toward higher levels of engagement.

The following are possible themes for the elementary years:

- Orderliness or organization
- Structure and function
- Variations and diversity
- Cause and effect
- Models
- Scale and perspective
- Systems
- Patterns of variations

## Middle School

Science in the middle school deepens and extends the understandings begun in the elementary years. It should accentuate the interests of young adolescents in relating topics to personal use and applying practical problem solving. The conceptual development continues with more rigorous investigations and experiments that focus upon social issues involving individual responsibilities and decision-making. At this time, students should begin to understand the limitations of science and the importance of respecting differing points of view.

In addition to those for elementary school, the following themes can be added or more fully developed:

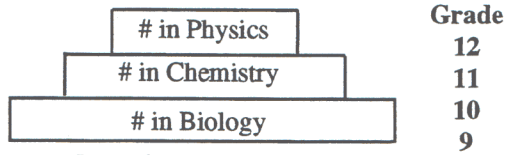
- Systems and interactions
- Stability and equilibrium, constancy
- Change

Even though the themes may be interwoven from one level of the science curriculum to the next, the development of the themes and their components varies with the developmental level of the student. For example, demonstrating observations is different for middle school students than for younger children.

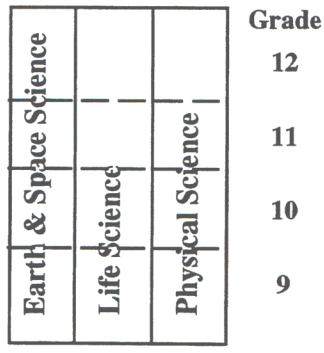
## High School

Historically, the arrangement of science course offerings and the restrictions placed on student selection for those courses have had an impact on the breadth and depth of learning. A preset sequence of courses is often the only arrangement available to students. Separations within and between science disciplines are the norm; integration with other subject areas, even with logical connections such as mathematics, is rare.

In the publication *Science for All Americans* from the Association for the Advancement of Science (AAAS), an alternative perspective for organizing science in high school suggests shifting the emphasis from a narrow




**Fewer students in each science, each year**




**Every student, every science, every year**

focus on a single discipline to an interdisciplinary approach, which might be organized around environmental studies, the social sciences, or the study of systems. Yet another view of organizing science from the National Science Teachers Association supports the presentation of topics in all the natural sciences to every student every year. The high school curriculum, coordinated with the middle school and elementary science curricula, should be nonrepetitive and should progress from the concrete to the abstract over the entire span of high school.

**In addition to those for elementary school and middle school**, the following themes may be more fully developed:

- Models and scale and their interrelationship and
- Constancy, evolution, and their interconnectedness.

## Designing a New Science Curriculum

One suggestion for the organization of the science curriculum takes into account the **developmental appropriateness** of certain concepts. For example, the study of patterns in life, Earth and space, and the physical sciences lends itself to development in the primary school much more than the study of constancy. However, concrete investigations of patterns lay the groundwork for the later study of more abstract concepts related to constancy. The science themes could be presented at each of the three levels - elementary, middle, and high school - with the topics used to explore those themes varying from year to year. In selecting topics or content, caution should be exercised to progress from concrete to abstract. Questions should be raised regarding the appropriateness of content traditionally used at certain grade levels. For example, is the study of atoms and molecules too abstract for elementary students? Are principles of physics and the activities that can convey those principles concrete enough for students in middle school? Among the criteria for the selection of content should be the allowance for **fewer topics and a more in-depth study** of those selected. Collaborative planning among teachers of all science levels, P-12, ensures a more integrated approach to developing the science curricula.

A second suggestion is to carefully **study the organization of topics** in science, especially at the high school level. Typically, biology has preceded chemistry which has preceded physics with fewer students enrolled in each subsequent class. As a result of that sequence and the demand for a high level of mathematics used in most current physics classes, many students have no further experience with principles of physics after middle school. Many also choose to enroll in a second or third course in the life sciences without having a single class in Earth and space or physical science.

It is recommended that science

- have a sequence appropriate to the learners' development;
- progress from concrete to abstract;
- explore topics from a variety of the natural sciences;
- be laboratory-based to connect concepts to hands-on experiences ;
- include interdisciplinary studies, such as environmental education and the social sciences; and
- be offered as part of every student's curriculum.

# National Standards

Many efforts are underway to identify the concepts that all students should know and be able to demonstrate during and at the end of their experiences in science. Various interest groups within the science disciplines are writing curricula and developing assessments to accompany each curriculum. The National Research Council is bringing together representatives of science associations to develop coordinated standards for curriculum, assessment, and teaching. The timeline for the entire project extends over several years with an anticipated dissemination of the first document by 1994.

The American Association for the Advancement of Science is also in the process of developing *Benchmarks for Science Literacy*. They will give guidance to science educators when determining content for curriculum, assessment, and instruction. Drafts of early documents are being reviewed and revised based on comments from science educators across the country.

Representatives from Kentucky's science education community continue to collaborate with members of the National Science Teachers Association, the American Association for the Advancement of Science, the National Science Foundation, and other professional organizations to ensure a close alignment between the emerging national standards and Kentucky's expectations for students.

# Closing Comments

In the selection and organization of the themes, concepts, and topics used in the curriculum, several words of caution should be heeded.

- The science curriculum should reflect what **all** students should know and be able to demonstrate. Science classes, comprised of hands-on experiences and heterogeneous groups, should be available to **all** students. In the sciences, it is important to emphasize the balanced, broad-based experiences rather than specializing in one area.
- Some topics presently included in elementary, middle, and high school science may be too abstract or even irrelevant to students' lives. Serious consideration should be given to a thorough examination of all topics, concepts, and themes as to their appropriateness for students.
- Efforts to ensure equity for minority students and girls in science and mathematics must begin at the elementary level. They must continue with middle school students who are beginning to explore career options and with high school students who are hesitant to continue in science.

Science, as a way of thinking, should be part of every person's repertoire. Learning the process skills and applying them to real situations are options all students should have. Schools must ensure that all students have access to science classes and have learned to apply the processes of science to problems and situations they will encounter in their lives. They also need to be prepared when making decisions regarding careers in science or science-related fields. Science provides the opportunities for students to develop problem-solving skills necessary to their everyday lives.

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.1: Students understand scientific ways of thinking and working and use those methods to solve real-life problems.

**Learning Links:** Bird-watching / Surveys / Medicine / Journals / Mystery Stories / Mental Health / Interviews / Trial and Error / Engineering / Technology / Criminology / Forensics / Social Sciences / Choreography

**Related Concepts:** Observing / Inferring / Measuring / Identifying and Controlling Variables / Designing Investigations and Experiments / Verifying Results


Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Design, conduct, and report an investigation or experiment.
- Identify variables that cause or influence an outcome.
- Infer and formulate explanations or predict an outcome based on data.
- Record and represent data in an organized form (e.g., tabular, graphic formats).
- Collect data by using a variety of observation techniques and measurement tools.
- Classify and order objects by one or more identifiable properties.
- Observe and communicate properties of objects or organisms using all senses.

- Design and conduct a controlled experiment based upon student-generated observations and hypotheses.
- Identify significant variables that affect the outcome of an experiment and design controls for the experiment.
- Formulate models to illustrate or predict phenomena.
- Interpret data to infer relationships and apply to new situations.
- Construct operational definitions to explain concepts or facilitate experiments/investigations.
- Classify objects using multiple criteria.
- Communicate measurements made with common and advanced technological tools.

- Design and perform an inquiry of a real-life situation which extends knowledge from a previous experiment or investigation.
- Use mathematical formulas to express relationships in new situations.
- Manipulate variables within an experiment to determine the effects of each on a phenomenon.
- Evaluate alternatives to the experimental method as a means of inquiry.
- Formulate a tentative conclusion based on limited data. Differentiate between correlation and cause-and-effect relationships.
- Evaluate a variety of quantified data to draw conclusions, infer relationships, and predict outcomes.

## Sample Teaching/Assessment Strategies:

**Collaborative Process**: Peer Tutoring • **Community-Based Instruction**: Networking • **Continuous Progress Assessment**: Observation, Portfolio Development, Performance Events/Exhibitions • **Graphic Organizers**: Mapping/ Webbing, Venn Diagram • **Problem Solving**: Inquiry, Formulating Models, Simulations • **Technology/Tools**: Computers, Manipulatives • **Whole Language Approach** • **Writing Process**

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Participate in a scientific study to solve a specific problem at a museum, zoo, or business.
- Invite a local author, poet, playwright, or artist to discuss nature stories and how he/she verifies information or does research before beginning a project.
- Participate in a monitoring network (e.g., Kentucky Water Watch Program) to investigate procedures used in research.
- Utilize environmental and outdoor educational facilities in your area (e.g., 4-H camps, YMCA camps, state/federal parks) as part of a project that involves data collection.

# Core Concept: Nature of Scientific Activity

## *Sample Elementary Activities*

- Identify a real-world problem (e.g., effects of soil acidity on seed germination, methods for erosion control) and design an experiment to test a possible solution. PE, OE
- Conduct experiments with plants, using soil, water, and sunlight amounts as variables. Record changes on a spreadsheet. Display results using computer graphics. PE, P
- Observe, chart, and explain changes that occur in an aquarium over a two-month period comparing factors such as sunlight, water temperature, plant life, and animal life. P
- Construct at least three different classification schemes (e.g., size, shape, color) for 20 or more building blocks. PE, OE
- Investigate the variables that affect the flight of a paper glider; then predict the effect of altering one variable. Verify or refute predictions. PE, P

## *Applications Across the Curriculum*

### Variations on a theme: Weather

**Language Arts**
- Listen, record, and/or collect different types of weather forecasts from newspapers, radio, or other sources. Analyze similarities and differences in reporting styles. P

**Mathematics**
- Observe, record, and graph daily weather for a specified time. Compare one set of collected data to that from another time. PE, P

**Social Studies**
- Correlate the topography of an area with its weather conditions. Use a topographical map to track a weather system across the country. PE, OE

**Arts and Humanities**
- Make musical instruments which mimic or represent weather sounds (e.g., rain sticks). Sing or play original or existing music which simulates weather sounds. P

**Practical Living**
- Illustrate relationships among climate, geography, and clothing styles. PE, OE, P

**Vocational Education**
- Investigate careers which are directly influenced by weather and invite people in those careers to class for a panel discussion about weather. PE, OE, P

## *Reflections*

Science is a way of knowing. Through science, a systematic procedure for studying problems and investigating to find answers has been developed. The procedure includes elements such as observing, collecting information, organizing the information, inferring, and predicting. Using the process, rather than merely memorizing the procedural steps, should be the classroom focus.

Students should make decisions about how their questions can be answered as they progress through school. These skills developed in science are not only applicable to topics and investigations in science classes, but also to other disciplines, whether it is social studies, vocational education, mathematics, or the humanities.

Working through the processes of science, students develop an openness to new ideas, a curiosity about their work, a sense of fairness and cooperation, and the ability to weigh evidence and data to develop conclusions. These skills are valuable tools for students as they become proactive learners.

Source: American Association for the Advancement of Science -- Science for All Americans

# Core Concept: Nature of Scientific Activity

## *Sample Middle School Activities*

- Classify a variety of objects based on observable properties (e.g., size, shape, color, texture). PE, OE
- Design and conduct a controlled experiment to explain the effects of companion planting as a means of pest control. Establish operational definitions for terms that will facilitate this experiment. Evaluate the effectiveness of companion planting compared to the use of pesticides. PE, P
- Formulate hypotheses and design an investigation that illustrates the reaction of a population of invertebrate organisms to various stimuli. PE, OE
- Identify the variables that affect the movement of a pendulum and design an experimental model (e.g., a playground swing). PE, OE, P
- Classify subjects with one or more identifiable properties (e.g., size, shape, color, texture, material, form, composition) while participating in a field study at a science-related industry, art gallery, children's museum, farm, or zoo. PE, OE, P
- Develop a survey instrument and conduct a classroom or school poll on a topic of interest (e.g., favorite pizza toppings, class elections). Draw conclusions, make graphic representations, and share the results with the class. PE, OE, P
- Determine the percent of water in different brands of popcorn. Correlate the percentage of popped to unpopped kernels and that relationship to the percentage of water in the kernels. PE

## *Applications Across the Curriculum*

**Language Arts**
- Write an article for a newspaper about the advantages of a hands-on science program. PE, P

**Mathematics**
- Determine the rate of flow from a single small hole in a water-filled, sealable plastic bag. Predict the amount of time needed for the bag to empty. Test your prediction. PE

**Social Studies**
- Compare the experimental scientific method with observation methods used by social scientists. Determine how the use of factual information is sometimes influenced by human perspective and/or emotion. P
- Analyze the political and economic systems of a foreign country by collecting and reading newspaper articles and observing trends. Make predictions about the country's future. OE, P

**Arts and Humanities**
- Design a futuristic musical instrument; communicate the mechanics of the design which produces sound. PE, P
- Listen to Holtz's *The Planets*. Compare the scientific and musical elements; create movement sequences illustrating the musical or scientific ideas. PE, P
- Determine the quantity of water needed to convert dry tempera paint to a fluid, opaque consistency. PE, OE

**Practical Living**
- Compare various cereal products for recommended daily allowances (RDA). Present results in chart form with recommendations for purchase. OE, P
- Test grooming products (e.g., soap, deodorant, toothpaste) for pH balance; interview appropriate specialists for recommended pH levels of products; determine which products are best for the human body. PE, OE, P

**Vocational Education**
- Determine the fat content of various types of meat and their relative digestibility. PE
- Investigate the volume of cooked and uncooked rice compared to raw and cooked pasta. Analyze any differences. PE

# Core Concept: Nature of Scientific Activity

## *Sample High School Activities*

- Design and carry out an experiment for the purpose of expanding existing knowledge developed through previous experimentation. For example, find an unresolved question in research materials and design an experiment to answer this question. PE, OE, P
- Examine a research article in a scientific journal. Identify the hypothesis, independent and dependent variables; study the data and evaluate the conclusions. PE
- Conduct a long-term water survey. Correlate fluctuations in biodiversity and other environmental influences with chemical analyses. PE, P
- Propose procedures a forensic chemist might follow to extract and identify blood samples. Simulate the scene of a crime; read the procedures for analysis to identify blood types. P
- Investigate treatment alternatives that may hold promise for individuals suffering from incurable diseases. Debate pros and cons of each treatment. P

## *Applications Across the Curriculum*

**Language Arts**
- Compare the quality of the water systems serving your county using past and current copies of *Kentucky's Environment Report.* Prepare a presentation for your local town council. Include a position paper. PE, P

**Mathematics**
- Investigate a method to determine the diameter of the earth or the distance between the earth and moon using principles of geometry. PE, P

**Social Studies**
- Conduct a survey to obtain attitudes and reactions concerning global issues (e.g., genetic engineering, invitro fertilization); present ways that students can positively impact future decisions. P
- Assess a crisis situation where limited resources for survival are available (e.g., plane crash, new colony). Propose resources necessary for survival. OE, P

**Arts and Humanities**
- Communicate scientific discoveries by creating an original product or performance using music, visual arts, drama or dance. PE

**Practical Living**
- Test the air quality of the community, compare results to professional tests, and make recommendations based on the combined results. PE, P
- Conduct lab experiments on textiles to determine the effects of various stain-removal products and procedures. PE, P

**Vocational Education**
- Determine the pH level and needed nutrients of soil samples. Test types of plants best suited to specific pH levels.
- Investigate and compare the environmental and economic ramifications of using one item (e.g., aluminum, paper plate) recycled ten times to the cost of using ten new items. PE, P
- Design and conduct an experiment using leavening agents. Summarize findings. PE, P

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation

**2.2: Students identify, analyze, and use patterns such as cycles and trends to understand past and present events and predict possible future events.**

**Learning Links:** Music / Language / Tangrams / Sentences / Quilts / Time / Statistics / Square Dance / Habits / Symmetry / Puzzles / Trends / Ethnicity

**Related Concepts:** Laws of Nature / Organic Cycles / Inorganic Cycles / Mathematical Patterns

***Elementary Demonstrators*** 

***Middle School Demonstrators*** 

***High School Demonstrators*** 

Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Make predictions (extrapolate and interpolate) based on patterns.
- Demonstrate relationships among patterns.
- Recognize, describe, and create patterns (e.g., repeating, developmental, behavioral, symmetrical, cyclical) of objects or events.
- Classify objects according to more than one property or attribute.
- Classify objects according to one property or attribute.
- Identify and communicate common attributes of items in a group.
- Use senses to observe items; communicate similarities and/or differences.
- Investigate the relationships and interactions of two or more patterns.
- Investigate the existence of small-scale variations within a large-scale pattern.
- Formulate a pattern which represents an observed set of occurrences (e.g., data tables, equations).
- Analyze collected data to discover patterns and predict outcomes.
- Identify causes of observed patterns.
- Predict trends or events, given sets of long-term or systemic data, and evaluate outcomes.
- Evaluate and represent possible correlations between sets of observed data.
- Demonstrate interrelationships among multiple cycles and one or more rhythms.
- Represent patterns using mathematical expressions.
- Compare and contrast regular, irregular, and cyclic patterns.

## Sample Teaching/Assessment Strategies:

**Collaborative Process** • **Community-Based Instruction**: Networking, Field Studies • **Continuous Progress Assessment**: Portfolio Development, Performance Events/Exhibitions • **Problem Solving**: Inquiry, Formulating Models, Research, Interviews, Surveys, Polls • **Technology/Tools** • **Whole Language Approach** • **Writing Process**

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Have the local agriculture extension agent lead your class on a field study of erosion patterns and prevention.
- Invite a police investigator to the classroom to discuss DNA fingerprinting, patrol patterns, crime investigation, and composite photos.
- Utilize courthouse records to study shifts in local population patterns to predict future trends.

# Core Concept: Patterns

## *Sample Elementary Activities*

- Create sounds using natural or man-made objects and then try to duplicate those sounds using different objects. Group the objects by similarity of sound produced and identify the characteristics the objects have in common. PE, P
- Vary the volume of water in a bottle to determine the effect on the pitch produced. Use findings to predict the pitch produced by an untested volume of water. PE
- Create a symmetrical pattern (e.g., quilts, paper snowflakes, attribute blocks) after studying other patterns. PE
- Study a stack of cubes with a pattern and predict the cubes that could be added at the beginning and end of the sequence. PE, OE
- Collect items in nature that have a definite pattern (e.g., spider webs, leaves, fish scales) and design a classification system. PE, P
- Investigate patterns related to human activities (e.g., climate, sleeping habits, schedules) and represent them using computer graphics. PE, P
- Obtain five photos taken or selected at random. Create a story, poem, or song about patterns discovered in the pictures. PE, OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Illustrate a calendar with poems reflecting moods during the year. P

**Mathematics**
- Observe and compare geometric patterns in nature. Find examples of the patterns in manufactured items or architecture. PE

**Social Studies**
- Examine and classify patterns found in rural and urban settings. PE

**Arts and Humanities**
- Make rubbings of items collected on a nature walk and describe the patterns discovered. PE
- Create a sound pattern using rhythm instruments. PE

**Practical Living**
- Interview family, friends, and neighbors for past and present recycling behavior. Predict future environmental impact based upon the trend. PE, P
- Use a microscope to observe patterns made by the weave in different kinds of fabric. Test the strength of the fabrics. PE, P

**Vocational Education**
- Identify characteristics of eroding and non-eroding terrain. Suggest actions to correct the erosion. PE
- Survey a multi-generational family's history of the incidence of tooth decay. Hypothesize and analyze differences between generations. P
- Brainstorm ways patterns of family life change as the seasons change (e.g., food, clothing, family activities). PE, OE

# Core Concept: Patterns

## *Sample Middle School Activities*

- Use a spreadsheet to record and tabulate data showing the following relationships: (1) time of day to temperature, and (2) time of day to kilowatt hours of electricity used in your home or school. OE, P
- Collect, display, and analyze data showing relationships among age, gender, and growth of humans from ages 6 to 40. PE, OE, P
- Determine and compare relative densities of different objects (e.g., lead, wood, oil, plastic). Display findings using computer graphics. Analyze observed patterns. PE, P
- Predict the weather using data collected from observations and measurements. Include investigations about the relationship between cloud type and air pressure. Display findings. PE, P
- Construct a shadow stick (gnomon) and measure shadows generated. Graph the data using computer graphics. Make inferences or predictions using the information. PE, P

## *Applications Across the Curriculum*

**Language Arts**
- Collect random observations from a walking tour. Classify the observations by one or more characteristics or properties. Display the observations and/or the classification system. PE, P

**Mathematics**
- Create a model of rabbit population growth to predict the number of rabbits after ten seasons. PE, P

**Social Studies**
- Analyze and chart economic patterns and cycles in American history, and explore interrelationships with concurrent political events. P
- Build a model rocket with a camera in the capsule. Use the rocket to photograph a land area. Examine the geographic features and create a scale model of the landscape from the photograph. PE, P

**Arts and Humanities**
- Create a museum display depicting or illustrating patterns evident in music, art, cultures, literature, drama, and dance. PE, P
- Draw visual patterns that you discover in nature (e.g., sedimentation layers, waves, crystals, honeycombs). PE, P

**Practical Living**
- Graph smoking and nonsmoking trends in the United States for the past 50 years. Analyze correlations in the research. OE, P
- Research the causes of the cycle of violence in relationships (e.g., dating, marriage, family). Investigate ways and means of breaking the violence cycle. Present findings to others (e.g., poster campaign for school awareness, article in school newspaper). P

**Vocational Education**
- Build a small motor and report on the effects of the magnetic field that cause the motor to run. PE, P
- Design disposable, environmentally safe packaging for an existing product. PE, P

# Core Concept: Patterns

## *Sample High School Activities*

- Predict future trends for environmental qualities (e.g., temperature, ozone, pollution) from evaluations of research data collected over a 100-year period. Access through telecommunications and CD-ROM. PE, P
- Determine the location of the epicenter of an earthquake by monitoring P and S wave patterns using a computer simulation. PE
- Predict oil consumption over a 100-year period using at least three different rates of increase by manipulating data recorded on a spreadsheet. PE, P
- Prepare a database to access information about chemicals found in the chemistry lab. Use software accessing MSDS (Materials Safety Data Sheet) forms to support the database. P
- Illustrate biological succession in your community (e.g., old field succession, pond succession, community succession) by producing a video. P

## *Applications Across the Curriculum*

### Variations on a theme: Urban Concepts

**Language Arts**
- Investigate and compare behavior patterns of literary characters who live in urban settings. Use literature from two distinct periods in history. PE, OE, P

**Mathematics**
- Design and conduct a survey on population growth and/or population shifts in selected urban areas. Process and report the information using a database. P

**Social Studies**
- Chart the changing nature of urban development (e.g., economic adjustments, territorial growth, demographic shifts). PE, OE, P

**Arts and Humanities**
- Create a museum display representing shifting urban population patterns. Include examples from music, art, literature, drama, and dance. PE, P

**Practical Living**
- Review typical urban family life cycle from time periods at least a century apart. Prepare a personal life cycle and compare it to those studied. PE, OE, P

**Vocational Education**
- Investigate trends in job types and availability in urban areas. OE, P

## *Reflections*

*Studying patterns gives students an awareness of the consistency of the universe. It establishes the basis for recognizing relationships, such as cause-and-effect and sequencing. Patterns are everywhere, and it is vital that students learn to make the connections necessary to see patterns and relationships. Some patterns, like the shapes of maple leaves from tree to tree, are obvious. Sometimes patterns are more elusive, such as the study of the pattern of ozone depletion geographically and over time.*

*As learners, students should be aware of constantly shifting and sorting information received through the senses, arranging and rearranging it in order to make connections. In this way, sorting and shifting, creating meaningful pictures of how things repeat, and looking for the way things are predictably connected, students seek and use patterns not only to learn new information, but also to interpret their world.*

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.3: Students identify and analyze systems and the ways their components work together or affect each other.

**Learning Links:** Multicultural / Politics / Computers / Cities / Government / Transportation / Manufacturing / Communication / Climate / Stock Market / Agriculture / Machines / Conservation

**Related Concepts:** Contexts for Systems and Interactions: Biological (e.g., ecosystems) / Physical (e.g., electrical) / Social (e.g., manufacturing)


Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Create a system.
- Investigate system feedback and self-regulation.
- Analyze how the properties of the components of a system affect their function within the system.
- Distinguish between systems and subsystems and describe interactions between them.
- Classify systems based on functions or properties.
- Communicate functions of a system.
- Identify components of a system.
- Recognize things that work together.
- Design a new system or modify an existing one. Analyze the effects and limitations.
- Evaluate the effects of subsystems and their components on a system.
- Investigate the role of energy flow in systems.
- Demonstrate how a single system can have multiple functions and applications.
- Investigate and illustrate a system; identify its components and interrelationships with other systems.
- Design and implement a series of systems with multiple subsystems to achieve an outcome.
- Differentiate between cause and effect in a malfunctioning system.
- Analyze the role of effective communication and feedback within and among systems.

## Sample Teaching/Assessment Strategies:

**Community-Based Instruction**: Field Studies, Service Learning • **Continuous Progress Assessment**: Portfolio Development, Performance Events/Exhibitions • **Graphic Organizers:** Heuristics, Venn Diagrams • **Problem Solving**: Inquiry, Investigation, Experimentation, Simulation, Formulating Models, Research, Simulation • **Technology/Tools** • **Whole Language Approach** • **Writing Process**

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- With the help of local officials study road, sewer, water, transportation, and telephone systems that serve your area.
- Invite local computer technology experts to present various computer systems.
- Ask a biologist, farmer, chemist, physicist, artist, or wildlife biologist to come to class to demonstrate and discuss interactions between humankind and nature.
- Ask a local city/county planner and an environmentalist to discuss the impact of development on the local environment.

# Core Concept: Systems and Interactions

## *Sample Elementary Activities*

- Using a variety of objects, design and construct a machine which can be used to elevate a box of books from the floor to a table. PE, P
- Identify subsystems in a habitat (e.g., pond, forest, aquarium) and investigate their interactions. PE, OE, P
- Complete an electrical circuit, identify its components, and describe evidence of their interactions. PE, OE, P
- Investigate the relationship among physical activity, breathing, and pulse rate. Use computer software to generate a 3-variable graph. PE, P
- Choreograph the movement and revolution of the earth to demonstrate the reasons why seasons change. PE, P

## *Applications Across the Curriculum*

### Variations on a theme: The Aquarium

**Language Arts**
- Build a class aquarium and keep a journal with daily observations. Describe evidence of interactions of subsystems within the aquarium. P

**Mathematics**
- Develop strategies to determine the amount of water in an aquarium. Consider the rocks, plants, and other matter in the aquarium. OE

**Social Studies**
- Design a flowchart illustrating a production/consumption chain for the class aquarium. PE, OE

**Arts and Humanities**
- Listen to the song "I Know an Old Lady Who Swallowed a Fly." Rewrite to illustrate the interacting subsystems in the class aquarium. P
- Design and conduct an investigation to measure the effect of color, shape, and texture on fish behavior in the aquarium. PE, OE, P

**Practical Living**
- Develop a chart illustrating costs of purchasing and maintaining various aquaria. PE, OE

**Vocational Education**
- Invent a tool to help clean the aquarium more effectively or quickly. P

## *Reflections*

*"What is it made of?" "How does it work?" Investigating answers to these questions leads students to an understanding of the interconnectedness of all things. No single object, organism, or idea exists without influencing or being influenced by something else. For this reason, the study of systems and interactions is important for students. They can begin to analyze the pieces and parts of things and how they work together, whether they are working with systems in the human body, parts of a machine, or the ideas of an argument.*

*In The Fifth Discipline, Peter Senge discusses his concept of systemic thinking in which no one thing stands alone. Every single thing is connected in overt and covert ways to many other things. Through the study of systems and interactions, students can begin to understand that each object or person has an influence—large or small, intentional or unintentional—on the entire system. With encouragement, students will learn to extend this search to understand the ways their entire world is connected.*

*Source: Senge — The Fifth Discipline, The Arts and Practice of Learning Organizations*

# Core Concept: Systems and Interactions

## *Sample Middle School Activities*

- Modify a circuit to do something different (e.g., ring a bell, flash a light). PE, OE
- Examine a system (e.g., machine, body system) which is malfunctioning. Speculate and infer the source of the problem, and suggest corrections and/or solutions. PE, P
- Evaluate and illustrate the relationship of human body systems by comparing them to the operations of a city. PE, OE, P
- Create/design an emergency alert system for the school to use during a power failure. Describe its strengths and limitations. Present the design to the principal and/or maintenance supervisor. P
- Investigate the impact of zebra mussels on fresh water aquatic ecosystems in the United States. Access research information through CD-ROM and/or telecommunications. P
- Invent a system to feed and water a pet while the family is on vacation. PE, P
- Design and build a telescope or microscope from common lenses and tubing. Determine limitations of the instrument when it is used in investigations. PE

## *Applications Across the Curriculum*

**Language Arts**
- Design a brochure to persuade people to protect a local endangered species. Present data to support its niche in the biome. P

**Mathematics**
- Build models of polyhedrals while investigating crystalline structures. P

**Social Studies**
- Analyze the effects of geography on social or economic systems in various world countries on the same continent. OE, P
- Chart examples of social systems which are portrayed in television programs. P

**Arts and Humanities**
- Create a rhymed couplet to communicate body systems. PE, P
- Demonstrate the various systems of showing value (e.g., hatching, cross-hatching, pointilism, shading). P

**Practical Living**
- Conduct a field study at a facility involved in food production (e.g., farm, processing plant). Create models that describe the system investigated. P

**Vocational Education**
- Compare the engine of a car to the human body. Use schematics to show the comparisons. PE
- Make a graphic representation of the systems involved that trace a product from producer to consumer. PE

# Core Concept: Systems and Interactions

## *Sample High School Activities*

- Analyze the facts surrounding the issue of importing foreign species into this country and the impact on the environmental system. Identify the questions that must be answered regarding the sale of exotic animals as pets. Using desktop publishing software, write a newspaper article about your findings. P
- Explain how your body systems interact to allow the assimilation, utilization, and elimination of dye used in a diagnostic procedure (e.g., radioactive dye used in diagnosing kidney stones). PE, OE, P
- Evaluate the effects of a breakdown in one component of a system or subsystem (e.g., liver in the human body) on the system as a whole and on its interaction with other systems. PE, OE, P
- Investigate the laws of physics most often employed in amusement park thrill rides. Using computer software, design a thrill ride. P
- Create a system which employs various convex and concave mirrors to increase the intensity of a beam of light. Investigate practical applications of the system. Design a tool or device, using the procedure. PE, P

## *Applications Across the Curriculum*

**Language Arts**
- Change a trait of a main character in a short story and rewrite the story using the new or enhanced trait. OE, P

**Mathematics**
- Determine the mathematical relationships that exist among the gears, gear ratio, gear size, distance, speed, and cadence of a multi-gear bicycle. P

**Social Studies**
- Illustrate graphically the variety of governments that have an impact on your life. P
- Illustrate how a law could be created through the local legal system. PE, P

**Arts and Humanities**
- Critique a professional performance (live or video) and identify the components (e.g., lighting, beat patterns of musical score, tonality of performers, design of the set) that created the holistic effect. Speculate how the mood or effect would change if components and their interactions had been designed differently. P
- Correlate a dance troupe's performing a ballet to a system, its components, and interactions. OE, P

**Practical Living**
- Research and track the health effects on humans of selected changes in the environment (e.g., a decrease in the ozone layer, herbicides that enter ground water). OE, P
- Illustrate the effects of smoking, drugs, and alcohol on prenatal development. OE, P

**Vocational Education**
- Design a warning label to be attached to a portable, multipurpose gasoline engine. PE, P
- For one month, record your blood pressure daily at the same hour. Also record your emotional state at that time (e.g., sad, happy, angry). Draw correlations between your emotional state and your blood pressure. P

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation

**2.4: Students use the concept of scale and scientific models to explain the organization and functioning of living and nonliving things and predict other characteristics that might be observed.**

**Learning Links:** Architecture / Photography / Transportation / Computer-Aided Design / Model Rockets / Maps / Musical Scores / Dollhouses / Theatre Sets / Flowcharts / Electric Trains / Sizing

**Related Concepts:** Models: Physical, Mathematical, Conceptual
Scale: Time Scales, Physical Dimensions, Measurement Scales (Fundamental and Derived Units)

***Elementary Demonstrators*** 

- Evaluate appropriateness of components and scale to a real object being modeled.
- Investigate the significance of perspective.
- Use models to depict the function of an object, event, or system.
- Represent a real event, object, or concept with a model.
- Investigate models to determine how things work.
- Investigate models that represent objects, events, or systems.

***Middle School Demonstrators*** 

- Investigate properties that change or remain constant with changes in scale.
- Evaluate the functions, behaviors, and limitations implied by a model.
- Formulate multiple perspectives through the use of a model.

***High School Demonstrators*** 

- Represent an idea, structure, or system with various types of models (e.g., physical, conceptual, mathematical).
- Identify assumptions underlying a model and evaluate their effects on the appropriateness of the model.
- Evaluate the appropriateness of the scale of a model and its effects on the model's behavior.
- Use a model to analyze or predict behavior of objects, materials, or living things.

Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

## Sample Teaching/Assessment Strategies:

**Collaborative Process**: Cooperative Learning • **Community-Based Instruction**: Field Studies • **Continuous Progress Assessment**: Conferencing, Self-assessment • **Graphic Organizers**: Advance Organizers, KWL • **Problem Solving**: Heuristics, Case Studies, Debate • **Technology/Tools**: Distance Learning, Telecommunications • **Whole Language Approach** • **Writing Process**

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Visit a planetarium to study available models of the universe.
- Locate local rocketry and/or airplane hobbyists who will demonstrate their models and explain how the different parts work together.
- Explore the use of topographical maps by different agencies in the community (e.g., phone company, gas company, soil conservation, municipalities, agricultural extension agency).

# Core Concept: Models and Scale

## *Sample Elementary Activities*

- Design and create a wave-generation system to investigate wave patterns, reflection, and refraction. P
- Create a topographic map of a 3-dimensional model of a hill, knob, or mountain. PE, OE
- Observe and illustrate a 3-dimensional object from different perspectives (e.g., top, front, bottom, sides). PE, OE, P
- Diagram the energy flow of a food web from the energy source to the final consumer. Include at least one producer, two consumers, and one decomposer in your diagram. PE, OE
- Find alternate routes to a specific location (e.g., home, cafeteria, playground). Draw a map to scale showing at least one route. PE, OE
- Construct a model of a building. Compare the model to a real structure. Identify the limitations and advantages of the model. P
- Compare photographs of objects to real things in terms of perspective, scale, proportion, dimension. Present your observations. PE, OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Create a body mask to represent a specific science concept. Write a story and use the mask to tell about the concept. P

**Mathematics**
- Map the school playground to scale. PE, P
- Draw a life-size model of a large animal (e.g., dinosaur, blue whale, elephant) in an open space (e.g., gym, ball field). Decrease the size of the drawing to a scale that will fit on an 8 1/2" by 11" sheet of paper. P

**Social Studies**
- Create a survey on a specific issue which samples a portion of the school population. Investigate various conclusions that might apply to the entire population. P

**Arts and Humanities**
- Observe and study types of cloud formations. Create models of the cloud types using various materials. PE, P
- Make a model of the solar system using other students to represent the planets. Choreograph movements to show the rotation of the planets and their moon(s). PE, P

**Practical Living**
- Design, build, label, and explain a cell model and its parts. PE, P
- Investigate the interactions that occur in a landfill by burying various types of trash (e.g., food, aluminum cans, styrofoam cups). Retrieve the trash after several months to observe the changes. PE, P

**Vocational Education**
- Prepare mock-up layouts of the school to help new students locate places and people. PE
- Use a sewing pattern to create a costume for a production. PE, P

# Core Concept: Models and Scale

## Sample Middle School Activities

- Design a scale model of an ideal middle school. Consult with an architect about your design. Present your plan to the school council or school board. PE, P
- Use simple machines to explain mathematical relationships (e.g., direct and inverse relationships). OE
- Investigate and describe the functions, behaviors, and limitations implied by body-system models. Use findings to determine the effectiveness of the models in communicating the concept. PE, OE, P
- Display various perspectives of a classroom (e.g., such as a teacher's view, students' views, the electrical system's view). PE, P
- Create a shadow box that allows viewing from multiple perspectives. Illustrate each perspective. PE, P
- Brainstorm various phenomena that could be modeled with a single object. P

## Applications Across the Curriculum

### Variations on a theme: Architecture and Design

**Language Arts**
- Create a database of analogies, similes, and hyperboles using architectural or construction terms (e.g., as hard as a rock). P

**Mathematics**
- Identify various structures whose designs are based on geometric shapes found in nature. Collect a series of pictures and draw the corresponding shapes to scale. PE, P

**Social Studies**
- Investigate the architectural environment of your community. Conduct a photo survey of the structures to compare style, age, and original purpose. Compile findings in a book for the local library. P

**Arts and Humanities**
- Compare the designs of various theaters and opera houses. Design a portfolio of the characteristics. P

**Practical Living**
- Chronicle the manner in which dollhouses have changed over the years. Build a futuristic dollhouse which incorporates designs you think will be part of a house in the 21st century. P

**Vocational Education**
- Design and build a scale model of a home typical of a foreign country. P

## Reflections

*Communicating an idea or concept to another person almost always involves using a model of some sort. It may be a three-dimensional representation of a cell or an analogy used to represent an idea. Why should students learn to use models? As they see the analogies created by teachers and are encouraged to create them for others, they learn to build models for their own learning. To investigate, design, and construct a model is to transform the abstract. It is one thing to imagine and to visualize an idea, it is quite another to actually communicate that image. Mental models serve the same purpose as the tangible ones. If students can create an accurate model, they can demonstrate what they have learned to someone else.*

*Constructing any model means paying attention to the original and using a scale which will accurately communicate the essential relationship among the elements being studied. The more accurate the relation of the model to the original, the greater the learning that results. Learning to make decisions about the scale and design of a model helps students see and interpret their world more accurately and fully.*

*Source: McKim— Thinking Visually: A Strategy Manual for Problem Solving*

# Core Concept: Models and Scale

## *Sample High School Activities*

- Create models of bridges, and test the structures to identify which one functions best. PE
- Develop two different types of models illustrating homeostasis. PE, P
- Redesign a model to a different scale (e.g., airplane, map); defend the appropriateness of the new model for a specific purpose. P
- Compare models used in the evolution of the atomic theory. OE
- Demonstrate and explain the effects of the volume of water, slope of a river, and substrate materials on a river's ability to erode the landscape. Use a stream table and document the demonstration in video form. P
- Use a recipe to illustrate stoichiometry (quantitative chemical properties and composition). PE
- Design and construct two types of models (mathematical, conceptual, physical) which illustrate the relative position and motion of the earth, sun, and moon. PE, OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Rewrite an early science fiction story using up-to-date, accurate information. OE, P

**Mathematics**
- Create a mathematical model representing the energy of an ocean wave. PE
- Use geometry to predict the position of the moon in the night sky at a given time based on the angular relationship of the moon, earth, and sun. Draw the corresponding moon phases visible from your location on the earth. PE, P

**Social Studies**
- Construct a model of a landfill that would reflect community needs and concerns. P
- Plan a political campaign for an elected official. Include illustrations of strategy, special events, schedules, and budgets. P

**Arts and Humanities**
- Create scale drawings of a stage setting for a school performance. Build a model from the drawings. PE, P

**Practical Living**
- Explore the concept of levers by determining the optimal limb and trunk position needed to generate maximum force production during weight-training exercises. P
- Create a scale model of a futuristic home. Design both the interior and exterior of the home. P

**Vocational Education**
- Design a program to lower the body's "set point" by ten pounds. Include maintenance procedures. P
- Build a geodesic dome. Investigate its effectiveness as a greenhouse design. PE, P

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.5: Students understand that under certain conditions nature tends to remain the same or move toward a balance.

**Learning Links:** Instinct / Friendship / Balance / Time / Communication / Pi $\pi$ / The Past / Emotions / Learning

**Related Concepts:** Physical Constancy (e.g., gravity, speed of light)
Biological Constancy (e.g., cell division, growth)


Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Investigate factors which may disrupt constancy and describe their effects in a steady state system.
- Investigate and describe steady state systems and components of a system that work together to achieve constancy.
- Describe an event or system that includes a constant process.
- Identify, observe, and communicate recurring events.
- Apply constancy concepts to make hypotheses and predictions.
- Investigate the characteristics and effects (e.g., nature, size, frequency) of a disruption to a steady state system.
- Analyze the relationship between scale and the appearance of constancy.
- Analyze the relationship between change and constancy.
- Analyze the processes which return a system to equilibrium following a disruptive occurrence.
- Analyze the relationships between cyclic subsystems and negative feedback as they contribute to the maintenance of equilibrium.
- Predict outcomes of a real-world situation, using universal laws.
- Analyze the concept of conservation in the universe.
- Evaluate systems to determine if they are steady state.

## Sample Teaching/Assessment Strategies:

**Collaborative Process** • **Community-Based Instruction**: Service Learning, Networking, Mentoring • **Continuous Progress Assessment**: Anecdotal Records • **Problem Solving**: Investigation, Simulation, Formulating Models • **Technology/Tools** • **Whole Language Approach** • **Writing Process**

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Visit one of the planetariums in Kentucky and investigate the constancy of the universe over time.
- Invite a soil conservationist, agriculture extension agent, or park ranger to explain how, why, and when system design is sometimes necessary to control erosion.
- Invite a representative of the Environmental Protection Agency (EPA) or Natural Resources and Environmental Protection Cabinet to demonstrate how pollution is detected, monitored, and corrected.

# Core Concept: Constancy

## *Sample Elementary Activities*

- Identify the self-regulating components of a system in your home or community that work to achieve a balance (e.g., thermostat on a heating system; traffic lights to control traffic patterns; time periods in sporting events). PE, OE
- Graph sunrise and sunset times for a period of 14 days. From the data, predict the sunrise and sunset times for each day of the following week. Verify your predictions by data collection. P
- Correspond with a pen pal in Hawaii via telecommunications. Describe and compare the sequence of seasonal changes in Kentucky and Hawaii. Analyze the effect on daily routines. OE, P
- Make a chart depicting your daily routine. Identify and record patterns. P
- Determine the influence of light and gravity on seed germination and growth. Use the information to select the best place in the school to grow plants. OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Read different versions of favorite fairy tales to determine elements which remain the same. Analyze why some elements changed. OE, P

**Mathematics**
- Compare your weight on Earth to your weight if you were on the moon or another planet. Analyze reasons for any differences noted. OE

**Social Studies**
- Analyze a report on the ability of the environment to rebound after a major disaster (e.g., volcanic eruption, oil spill, hurricane). OE, P

**Arts and Humanities**
- Create a mural illustrating your classroom without gravity. PE

**Practical Living**
- Illustrate how pulse varies around a stable norm. Collect data while sitting, lying down, working, and standing during different times of the day. PE, P

**Vocational Education**
- Record and graph a six-second pulse count daily for one week. Explain observations. P
- Identify local endangered species. Present findings of efforts to bring them to a relatively constant state. P
- Investigate homeostatic examples within a body (e.g., body temperatures). P

# Core Concept: Constancy

## Sample Middle School Activities

- Describe the probable appearance of the night sky in 500 and 5000 years when viewed from a specific latitude. OE
- Analyze the components of plate tectonics to describe why the earth's surface area remains constant even though the surface changes. Access supporting information using CD-ROM. OE, P
- Predict the position of one of the planets in our solar system in 90 days and 90 years (Earth time) by applying concepts of constancy and using the rate of its revolution. PE, P
- Communicate via telecommunications with a pen pal in the Southern Hemisphere. Explain how the motion of the earth affects stellar and lunar observations and the seasons from each location. P
- Investigate and explain what happens when effervescent antacids are placed in water. Use a balance and the Laws of Conservation to justify the explanation. PE, P
- Communicate the manner in which topography influences changes in weather even though the climate of an area remains relatively constant. OE, P

## Applications Across the Curriculum

**Language Arts**
- Design an investigation to demonstrate to a primary student why there may be a difference in temperature between the deep and shallow water of a swimming pool. PE, P

**Mathematics**
- Create a balsa wood structure at least .5m tall to support 2kg of mass. Explain why one particular infrastructure design works better than another. PE, P

**Social Studies**
- Explore the disruption in South Africa's long-standing apartheid system of government. Produce a fictional diary of life before and after the governmental change. P

**Arts and Humanities**
- Investigate the relationship between noise and music. PE, P

**Practical Living**
- While performing static and/or dynamic balances (e.g., balance beam, skate board), explore and demonstrate the principle of the center of gravity. OE, P

**Vocational Education**
- Maintain a 90-day mood chart to identify a pattern of constancy of your emotions. P
- Evaluate global conservation practices and use of natural resources. Compare to local practices. P
- Examine x-rays of a fracture taken throughout the healing process. Observe and analyze the steps in the healing process. PE, P

# Core Concept: Constancy

## *Sample High School Activities* 

- Create a computer simulation to demonstrate how alterations in input affect the output of chloroplasts during photosynthesis. Predict implications of the effect on agriculture. P
- Assume the role of a United States patent office reviewer; respond to a proposal for a machine which claims to produce more energy than it consumes. Justify your decision to accept or reject the patent. PE, OE, P
- Describe the processes that take place in body systems as they return to homeostasis following the ingestion of large quantities of concentrated sugar solutions during diabetes diagnostic tests. PE, OE, P
- Predict the climate in Kentucky 100 years from now, assuming current trends in ozone depletion and global warming continue. P
- Present a chemical magic show illustrating a variety of science concepts to a primary classroom. PE, OE, P

## *Applications Across the Curriculum*

### Variation on a theme: Disasters

**Language Arts**
- Read a variety of fictional and nonfictional accounts of a major disaster. Analyze the similarities and differences of the responses of the victims. OE

**Mathematics**
- Chart the frequency of occurrences of a particular type of natural disaster in a specific geographic region. Research possible explanations for the causes. PE, P

**Social Studies**
- Analyze a report on the ability of the environment to rebound from a major disaster (e.g., volcanic eruptions, oil tanker spills, hurricanes). PE, OE, P

**Arts and Humanities**
- Locate examples, using a CD-ROM, of natural disasters depicted in art. Create a HyperStack of the examples according to personally developed criteria. Use the HyperCard stack as part of a multimedia presentation. P

**Practical Living**
- Prepare and distribute a pamphlet of quick-response community agencies and services which could be used in the event of a community disaster. P

**Vocational Education**
- Volunteer to be part of an emergency response or disaster readiness team in your community. P

## *Reflections* 

*"The only constant is change." As students study any system which is attempting to maintain equilibrium, they discover the interrelatedness of constancy and change. Systems may range from a spinning gyroscope to a person's mental health, from a nuclear reaction to the weathering of mountains. Trying to determine if a system is in a state of balance requires the application of the processes of science—observing, collecting, recording, and interpreting data.*

*Using the skills involved with determining constancy can challenge a student to look for balance in many aspects of learning. The idea of constancy is a viable candidate as a theme for a cross-disciplinary unit.*

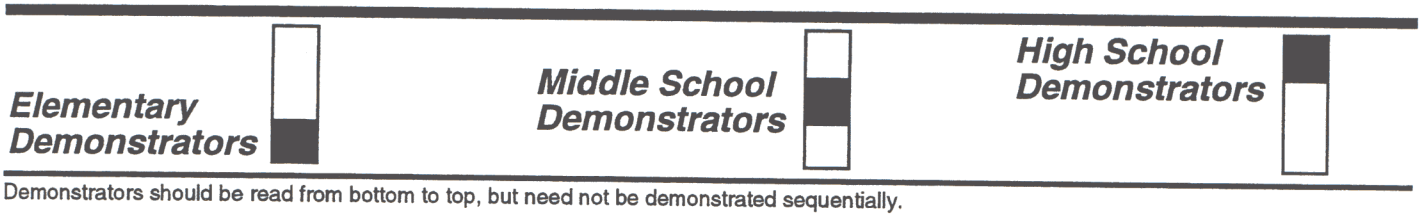
*Change is also an element of constancy that must be integrated into the study of steady state systems. Without looking at how things change, students may not understand how they stay the same, nor understand the broad truth of the saying "The more things change, the more they remain the same."*

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.6: Students understand how living and nonliving things change over time and the factors that influence the changes.

**Learning Links:** Civilization / Computers / Language / Agriculture / Artistic Design / Music / Knowledge / Communication / Travel / Exploration / Communities / Culture / Revolution

**Related Concepts:** Life Changes / Adaption / Natural Selection / Physical and Chemical Change / Radioactive Decay / Erosion




Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Describe situations where one change causes another change.
- Investigate variables that influence change over time (evolution).
- Describe the sequence of steps in a change process.
- Identify and predict small and large scale changes.
- Observe and communicate change over time (evolution).
- Evaluate the impact of a disruption on the evolution of a system.
- Predict the future state of an evolving system.
- Investigate evolutionary change, and evaluate factors (e.g., random and predictable) responsible for change.
- Illustrate evolution in a variety of contexts (e.g., biological, physical, social).
- Propose and defend a change that redirects evolution.
- Evaluate how change in one system influences change (e.g., small and large scale) in another.
- Analyze factors that influence the evolution of a system.
- Demonstrate how sequence and rate affect change in a system.

## Sample Teaching/Assessment Strategies:

**Collaborative Process**: Reciprocal Teaching • **Community-Based Instruction**: Service Learning • **Continuous Progress Assessment**: Portfolio Development, Anecdotal Records, Self-assessment • **Graphic Organizers**: Flowchart, Storyboard • **Problem Solving**: Brainstorming, Future Problem Solving • **Whole Language Approach** • **Writing Process**

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Invite a grandparent to class to share photographs of his/her family members' personal characteristics, clothing styles, and hair styles, and how these have changed over time.
- Survey the community for changes in architectural styles of homes, office buildings, and schools.
- Invite a retired physician, a practicing physician, and a recent graduate to discuss differences in medical diagnoses and treatments.

# Core Concept: Evolution

## *Sample Elementary Activities*

- Examine and discuss drawings of M.C. Escher (tessellations). Create a drawing or word puzzle that shows minor changes which become more evident over time or space. PE, P
- Conduct an environmental impact study on the location selected for a new school. PE, P
- Investigate the effects of placing ice cubes in different locations for melting (e.g., in a cup, in water, in sunshine, on the table, in your hands). Construct an ice cube keeper, evaluate its effectiveness and communicate the results. PE
- Take pictures or collect artifacts or other data which shows the decay of a leaf, food, log, or tree. Illustrate the role of decomposition in the food and mineral cycle. P
- Compare a person's present physical characteristics to his/her baby picture. P

## *Applications Across the Curriculum*

### Variation on a theme: Evolution of the Individual

**Language Arts**
- Analyze changes in a character from the beginning to the end of a novel. PE, OE, P

**Mathematics**
- Create a time line of events in your life. PE, OE, P

**Social Studies**
- Identify and predict short-term and long-term changes in yourself. OE, P

**Arts and Humanities**
- Prepare a photographic biography or autobiography. P

**Practical Living**
- Develop a personal plan for physical conditioning and chart the results over time. PE, P

**Vocational Education**
- Investigate the changes in equipment for sports or personal physical fitness in a 20-year period. PE, P

## *Reflections*

*As students become familiar with the evolutionary process in traditional, academic study units, they become acutely aware of the change process and the implications of change. Studying the change in a car's noisy engine, in the history of an ancient civilization, or in the behavior of a weather system helps students grasp the entire concept of change and the application of this scientific principle to other aspects of their studies and their lives. Scientific processes are applied throughout the study of change because so much depends on questioning, testing, analyzing, and revising information to determine whether change exists, or the degree to which it is occurring.*

*The study of change, whether considered macrocosmically or microcosmically, is significant to the understanding of systems and their interactions, identifying patterns, and recognizing constancy. Studying causes and effects of change leads to an awareness of the constancy of change itself.*

# Core Concept: Evolution

## *Sample Middle School Activities*

- Investigate a physical change in the local environment; document (e.g., series of pictures) the changes; measure the rate of change; describe the causative agents, and predict future changes based on the investigation. PE, OE, P
- Design and conduct an experiment to examine the effect of various factors (e.g., sunlight, water, vinegar, air) on the rate of decay of different kinds of trash (e.g., plastic, paper, organic). PE, OE, P
- Predict and model the possible location of the earth's land masses one million years from now. Defend your predictions using computer simulations. OE, P
- Predict the size of a tree, in five-year intervals, based on tree-ring data and climatic influences. OE
- Illustrate the evolutionary process of ocean sand as it makes its journey from a mountain rock. OE
- Collect fossils and compare them to similar organisms found today. Infer conditions which caused observed changes. P
- Locate and describe examples of evolutionary changes in our world today (e.g., technology, political systems, populations). OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Create an exhibit of changes in fads among teenagers over the past 50 years. Include written explanations. P

**Mathematics**
- Compare the present graduation requirements in mathematics to requirements before 1980. P

**Social Studies**
- Trace a fictional or historical person's family tree to analyze the evolution of cultural practices, changes in customs, family lifestyles, or parenting routines through successive generations. P

**Arts and Humanities**
- Hypothesize the effects of acid rain on architectural structures. Design an investigation to test the hypothesis. PE, OE, P
- Use a "morphing" computer program to change images of objects or people in your class. P, PE

**Practical Living**
- Brainstorm to identify items (e.g., telephone, television, cars, computers) that have evolved quickly. As a result, examine how each has improved or changed human life significantly. OE, P
- Research the evolution of common products, trends, and fads. P

**Vocational Education**
- Chart the evolution of the computer. Predict possibilities of applications of computers in the future. OE, P
- Prepare a time line of types of communications (e.g., percussion, written, electronic) from prehistoric times to the present. P
- Research the history of some aspect of health (e.g., anesthesia). Prepare a mural, series of cartoons, or drama showing stages of development. P

# Core Concept: Evolution

## *Sample High School Activities*

- Write a proposal requesting research funds for a town that has an epidemic health problem related to mosquitoes and an environmental problem related to insecticides. P
- Predict the issues which might be encountered by a research team in 2061 that has discovered, through bioengineering, a way to extend the human lifespan by approximately 25 years. Debate the economic, health care, cultural, political, and ethical ramifications of publishing and implementing the technique versus destroying your work. PE, P
- Predict how the depletion of the ozone layer is likely to affect you at age 50 if the present rate continues. Present the predictions in the form of a short story. P
- Do a qualitative analysis on an effluent of a local industry. PE, OE, P
- Investigate an existing system (e.g., economic, technological, political) in your community; analyze factors influencing its evolution, and communicate the impact of the change on the community as a whole. P
- Examine and illustrate graphically the correlations of a stream's velocity and width to its age. P

## *Applications Across the Curriculum*

**Language Arts**
- Chronicle the evolution of the detective mystery story. P

**Mathematics**
- Graph a mathematical function to demonstrate entropy. P

**Social Studies**
- Interview representatives of governmental agencies to assess the changing role of government since 1900. Compile the interviews into a single video. P
- Debate whether scientific advancements solve problems or create new ones. PE, P
- Correlate the evolution of manufacturing, communication, and travel to the changing lifestyles of Americans over the last 200 years. P

**Arts and Humanities**
- Create a photo essay or a documentary which depicts the evolution of something of personal interest (e.g., world history, communication, entertainment, science). PE, P

**Practical Living**
- Research the evolution of incidence of HIV/AIDS among teenagers. Present your data graphically from various predictions based upon the possible social approaches to the problem. OE, P
- Create clay models depicting the stages of prenatal development. PE

**Vocational Education**
- Examine the changes in procedures used to improve specific characteristics in breeds of various animals and plants. P
- Research and report on the historical development of the concept of preventive medicine. Analyze past practices in light of present knowledge. P

# Notes

# Mathematics

## Testimonial From the Mathematics Classroom

*When I started teaching, I modeled my teaching style after my former teachers. I followed curriculum guidelines and covered as much of the textbook as possible. I was a chalk-and-talk teacher who taught skill-and-drill mathematics. I explained and worked examples for my students and then assigned problems from the textbook. I honestly felt I was being an effective teacher. But I worried about the students who did not participate, who gave up easily, and whose answers made no sense at all. These students showed a lack of confidence in their skills and their abilities to do mathematics. They were also bored with the never-changing routine of the traditional mathematics classroom. I began to think about ways to engage all my students.*

*I realized I had to focus less on covering the material and more on students' understanding of the mathematics concepts. I observed that not all of them learn through lecture and sitting in straight rows. Since they enjoyed working together, I tried letting them work in cooperative groups with hands-on activities which allowed them to demonstrate their understanding of the concept and the way it applies to real life. Through professional development and working with colleagues, I learned to incorporate writing to give students opportunities to communicate.*

*Now, to accommodate my students' varied learning styles, I routinely use manipulatives, videos, field studies, computers, and calculators in my classroom. New methods of assessment, such as performance events and open-response questions, also allow students to demonstrate what they have learned. Each student keeps a working folder, and through conferencing, we screen the contents periodically and move entries to their mathematics assessment portfolio.*

*My students have some choices as well as input, and I believe that they have a better understanding of mathematics. I will continue to grow with them and try new ways to provide opportunities for success.*

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## Mathematical Power For All Students

*Mathematics must become a pump rather than a filter in the pipeline of American Education...More than any other subject, mathematics filters students out of programs leading to scientific and professional careers.* (7)*

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The objective of mathematics education envisioned in the two National Council of Teachers of Mathematics (NCTM) standards documents–the *Curriculum and Evaluation Standards for*

*School Mathematics* and the *Professional Standards for Teaching Mathematics*–is the development of mathematical power by ALL students. Features of this new power in mathematical learning include the following ideas adapted from the Mathematical Sciences Education Board (MSEB):

- Mathematics is much more than mere computation.
- Communicating–reading, writing, and speaking–is a basic mathematical skill.
- Mathematics helps students understand and explain the world.
- Fingers and counters are great tools for doing simple mathematics.
- Calculators are to pencil and paper what automobiles are to horses.
- All students can learn more mathematics through hands-on activities.
- Mathematics is learned better in groups.
- To know mathematics is to do mathematics.
- Mathematics done in school should be like mathematics used outside school.

Mathematical power means being able to explore, conjecture, reason logically, and use a variety of mathematical methods effectively to solve nonroutine problems. Students should participate in varied interrelated experiences that result in their

- learning to value mathematics,
- becoming confident in their ability to do mathematics,
- becoming mathematical problem solvers,
- learning to communicate mathematically, and
- learning to reason mathematically.

## Goals For An Information Society

*"By the end of the century, approximately two-thirds of all work will be information work."*
**Harland Cleveland**
**Dean of the Hubert Humphrey School of Public Affairs**
**University of Minnesota, 1985**

Mathematics is the language of the 21st century. In this "Information Society," computers, videos, and television have become dominant technologies. Today, the ability to understand and use mathematics is as important as the ability to read. New societal goals for education include 1) mathematically literate workers, 2) lifelong learners, 3) equitable opportunities, and 4) an informed electorate. All citizens will need to have mathematical skills to understand financial reports, political polls, debates about AIDS testing, the federal deficit, probabilistic inferences such as DNA fingerprinting, environmental issues, and the concepts of chance. Daily bombardment with conflicting quantitative information requires awareness of both the power and the limitations of mathematics. In tomorrow's world the best opportunities for jobs and advancement will go to those prepared to address quantitative, scientific, and technological issues. Mathematical power provides the key to these opportunities.

# KERA Goals For Learning Mathematics

As mathematics becomes more than calculation, education in mathematics must become more than mastery of arithmetic. Geometry, measurement, chance, and data analysis are as important as calculation in achieving mathematical power. To prepare students to use mathematics in the 21st century, today's curriculum must invoke the full spectrum of the mathematical sciences. The six KERA learning goals support these expectations for the mathematics curriculum.

Mathematics spans all KERA learning goals. In Goal 1 students apply mathematics skills in processing information and ideas. The Goal 2 mathematics concepts – **number, procedures/ operations, space and dimensionality, measurement, change, mathematical structure, and data** (probability and statistics) – were developed from the NCTM *Standards* and the National Academy of Sciences publication *On The Shoulders of Giants*. Some of these concepts are content-oriented; others are process-oriented. Students need opportunities to work independently (Goal 3), collaboratively (Goal 4), in problem-solving situations (Goal 5), and in real-life situations (Goal 6) using the skills and concepts from Goals 1 and 2. Only in this context will all students meet the high expectations set by KERA and be successful and confident in themselves as learners.

# Assumptions About Students Learning Mathematics

*One can hardly blame students for not becoming interested in mathematics if they rarely see evidence of its full power and richness.* (43)*

The following assumptions were made in the development of the NCTM *Curriculum and Evaluation Standards for School Mathematics***. They also governed the shaping of the Kentucky mathematics academic expectations which are closely aligned with the *Standards*. To transform the mathematics classroom into a hands-on, minds-on environment, the mathematics community

**assumes that all young children**

- like mathematics;
- do mathematics naturally;
- have a positive attitude toward mathematics;
- see and discover patterns;
- make conjectures based on observation;
- have confidence in themselves and enthusiasm for doing mathematics;
- need to use manipulatives, calculators, computers, and other tools to solve problems; and
- make natural connections between mathematics and other subjects.

**assumes that middle school students**

- need a mathematics curriculum which engages students physically and intellectually;
- need to explore and make sense of their world;
- need a mathematics curriculum with a broad, integrated view;
- need to experience the full breadth of relevant mathematics;
- need to see the interrelationship of mathematics with technology;
- are motivated by real-world problem situations;
- need to understand numerical and spatial concepts to prepare them for more abstract mathematics; and
- need to make connections between mathematics and other subjects.

**assumes that high school students**

- will have experienced mathematics in the context of the broad, rich curriculum outlined in the K-8 NCTM *Standards*;
- need enrichment and extensions of a variety of content;
- need to investigate and solve problems in real-world contexts;
- need to experience a curriculum which emphasizes conceptual understandings, multiple representations, mathematical modeling, and problem solving;
- need to use graphing calculators and computer utilities; and
- must be equipped with options for further education and career changes.

Throughout grades P-12, a variety of instructional methods should be used in classrooms in order to

- cultivate students' abilities to investigate, make sense of, and construct meanings from new situations;
- make and support arguments for conjecture; and
- use a flexible set of strategies to solve problems from within, across, and outside mathematics.

# Implications For Developing Local Curricula

## Overlapping Topics and Demonstrators

The KERA academic expectations for mathematics are a mixture of content and process. Just as the academic expectations overlap, so do some of the demonstrators. It is not possible to place each demonstrator under just one academic expectation to the exclusion of all others.

For example, the demonstrator "Extend and create patterns and generalize structures from patterns" could be addressed in all of the following academic expectations: **Number, Procedures, Measurement, Space and Dimensionality, Change**, and **Structure**. Examining the classification of quadrilaterals could be a patterning activity under either **Structure** or **Space and Dimensionality**. Also, demonstrators related to patterns, functions, or properties could be referenced under either **Change** or **Structure**.

The goal in the development of the mathematics demonstrators, regardless of their categorization, is that students have the opportunity to experience all mathematical topics. At the local level, curriculum developers need to address this issue.

# Developmental Design

Teachers should note that on each Goal 2 mathematics demonstrator page, an attempt has been made to write an entry level demonstrator at the bottom left of the elementary column and an exit demonstrator at the top right of the high school column; however, all demonstrators are **not** presented sequentially. (Refer to the format explanation and graphic on page 10).

In learning all mathematical content, students should move developmentally from the use of concrete and pictorial representations to more abstract thinking. For example, under **Data**, students do not have to construct displays of data before they can formulate problems that involve data; however, developmentally, they should move from tallying and counting to plotting and graphing. As another example, in studying **measurement**, students should first identify measurable attributes of objects and use nonstandard and standard units before applying and deriving formulas for measurement applications. There is also an appropriate developmental sequence in studying **space and dimensionality** (geometry). The van Hiele model (1984) describes five levels of geometric development which progress from visualization through analysis to formal aspects of deduction.

In the past, estimation was not considered an integral part of school mathematics. Its importance has been recognized as it interacts with number sense and spatial sense to help children develop insights into concepts and procedures. Estimation needs to be an ongoing part of the P-12 curriculum. It is not a "topic" to be taught in isolation within an academic expectation, but should be threaded through all mathematical topics.

As teachers develop their own curricula, the above factors should be considered. The goal is to provide all children with a rich, meaningful background in mathematics.

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*from *Everybody Counts: A Report to the Nation on the Future of Mathematics Education*, National Research Council, 1989.

**Curriculum and Evaluation Standards for School Mathematics*, National Council of Teachers of Mathematics, 1989.

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.7: Students understand number concepts and use numbers appropriately and accurately.

**Learning Links:** Astronomy / Polls / Population Studies / Elections / Life Cycles / Lotteries / Economic Trends / Stock Market / Temperature / Banking / Recipes / Sports Statistics / Travel

**Related Concepts:** Multiple Representations / Mathematical Notation / Number Relations / Equivalent Forms / Number Sense / Estimation / Ratio / Infinity / Number Theory / Limit / Number Systems

***Elementary Demonstrators*** 

***Middle School Demonstrators*** 

***High School Demonstrators*** 

Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Recognize integers.
- Investigate, model, apply, and communicate multiple representations of whole numbers, fractions, and decimals.
- Explore estimation strategies and determine when an estimate is appropriate.
- Construct number meaning and interpret the multiple uses of numbers through real world experiences emphasizing the relative magnitude of numbers.
- Investigate number systems (zero, grouping, and place value) and operations.
- Explore, group, identify, and classify sets of objects without numbers and then with numbers.
- Count forward, count on, count back, and skip count.
- Investigate infinite progressions using number lines and geometric representations.
- Investigate models of irrational numbers (e.g., pi, square roots).
- Use estimation to check the reasonableness of results.
- Develop and apply number theory concepts (e.g., factors, primes, multiples).
- Interpret and use appropriate mathematical notation for numbers (e.g., %,!, /, $\sqrt{}$ ).
- Model, communicate, and apply multiple representations of rational numbers.
- Explain, demonstrate, and model positional value (place value, exponents, number line, scientific notation).
- Investigate and communicate the concept of limit.
- Recognize situations which can be represented by complex numbers.
- Communicate, model, and apply multiple representations of real numbers.
- Determine reasonableness of results by estimation.
- Justify and communicate answers and solution processes.

## Sample Teaching/Assessment Strategies:

**Collaborative Process**: Cooperative Learning • **Community-Based Instruction**: Field Studies, Networking • **Graphic Organizers**: Mapping/Webbing • **Problem Solving**: Brainstorming, Inquiry, Questioning, Future Problem Solving, Formulating Models • **Technology/Tools**: Manipulatives, Games • **Writing Process**

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Invite individuals to class whose careers involve working with numbers (e.g., banker, accountant, IRS representative, delivery agency employee, or sports statistician) to discuss the importance of numbers.
- Serve as interns within city hall and help the town clerk with bookkeeping.
- Ask a representative from an agricultural agency in the community to discuss livestock marketing and margins of profit for different animals.
- Participate in a variety of organized mathematics challenges/competitions (e.g., KCTM Math Bowl, Math Reach, MATHCOUNTS).

# Core Concept: Number

## *Sample Elementary Activities*

- Make a special book that contains information about numbers (e.g., age, height, phone, strength). P
- Estimate how large a scale model of the United States would have to be if 1" represents 1 mile. Determine the actual distance using a trundle wheel to mark off length. Adapt scale to fit a smaller area. PE, P
- Divide a set (group) of raisins into fractional parts (e.g. , equally divide the group of raisins into three parts). Extend by showing raisins to represent a decimal (from a set of 10 or 100 raisins). PE
- Play the donut factory game. Roll number cubes to collect a number of donuts (Cheerios) and package them into sets of 5 using portion cups. After collecting 5 portion cups, place into a carton (plate). The object is to fill a carton. This may be played in any base. PE
- Show 10 ways to model the number 45 by using manipulatives (e.g., base 10 blocks), pictures, and writing. Communicate and compare the representations. OE, P
- Identify the different ways numbers are used in a newspaper. OE
- Determine different ways to estimate the number of beans in a jar. OE

## *Applications Across the Curriculum*

### Variations on a theme: Recipes

**Language Arts**
- Watch someone preparing one of your favorite foods. Write a description to tell someone how to prepare the recipe. PE, P

**Science**
- Estimate the amount of ingredients necessary to feed your class or school a favorite food. OE

**Social Studies**
- Find and prepare a recipe written using metric measurements. PE

**Arts and Humanities**
- Prepare a classroom cookbook of favorite foods. Include drawings or photos, tasting reviews, and recipes. Classify the recipes in a variety of ways. PE, OE, P

**Practical Living**
- Compare grams of fat, sugar, and nutrients of selected recipes from your cookbook. Graph the results. PE, P

**Vocational Education**
- Prepare some of your favorite recipes to share with the class. PE, P

## *Reflections*

*Basic understanding of the concept of numbers begins with counting, set theory, and one-to-one correspondence proceeding to rational, real, and complex numbers. Young students must understand the relative size of all numbers, especially those which are very large or very small. Older students must understand the part-whole relationships in rational numbers. Finally, all students must eventually understand the relationship among whole numbers, integers, rational numbers, real numbers, and complex numbers.*

*Recent studies suggest that not only must students be schooled in an understanding of number concepts, but they must also develop an attitude of familiarity and comfort with the concepts. A proven strategy for instilling positive attitudes and comfort about mathematics is the use of cooperative learning groups in the classroom. These groups focus their energies on open-ended problem solving with the emphasis on the strategies used to solve the problems, not just finding the answers.*

*Source: National Council of Teachers of Mathematics (NCTM), Curriculum and Evaluation Standards*

# Core Concept: Number

## *Sample Middle School Activities*

- Simulate the application of square roots/irrational numbers by constructing line segments (using Pythagorean Theorem) on geoboard or dot paper. P
- Represent integers using colored chips. Represent positive integers with one color and negative integers with another color. PE
- Explain the placement of the decimal point in the product of 2 decimal numbers using decimal squares (base 10 blocks). (e.g., 0.2 x 0.3 = 2/10 x 3/10 = 6/100 = 0.06) OE, P
- Communicate a play-by-play description of a football game using a number line and integers. P
- Build all the possible rectangular arrays using 1 sq. unit, 2 sq. units, and so on. Find a relationship between prime, composite, and square numbers with the arrays. PE, P
- Explain how to solve a mathematical problem using audio or video media. PE, P
- Search periodicals using CD-ROM to locate uses of scientific notation. PE

## *Applications Across the Curriculum*

**Language Arts**
- Write poems or limericks about math topics or ideas or geometric figures: "There was a math figure named Circle..." P
- Create word problems based on characters, situations, and settings from children's literature . OE

**Science**
- Estimate and then calculate the number of stairsteps needed to reach from the earth to the moon. P

**Social Studies**
- Graph relevant statistics of different countries such as population, natural resources, wealth, and standard of living. Draw conclusions. OE, P

**Arts and Humanities**
- Select one pair of complementary colors. Let warm color represent positive integers and cool represent negative integers. Mix positive and negative in equal parts to create a neutral (grey). Make a painting using only those two complements. (Warm colors advance, cool colors recede and neutrals remain in the middle ground.) PE, OE, P

**Practical Living**
- Compute personal expenditures for several months and then compute the average per month. PE
- Analyze and compare two different size bottles of aspirin as to number of doses and unit prices. Compute unit price of each dose contained in each container. P

**Vocational Education**
- Bring in telephone and utility bills. Find cost per minute of long distance calls, and per kilowatt-hour of electricity from utility bills. PE, P

# Core Concept: Number

## *Sample High School Activities*

- Graph $Y=1/(x^2+1)$ exponent on a graphing calculator. Set the range for x from -5 to 5 and the y from -1 to 2. Translate graph from calculator to grid paper. Count the number of the rectangles under the curve to estimate the area under the curve. OE
- Represent complex numbers on polar graph paper and relate them to blips on a radar screen. PE, P
- Develop strategies for estimating large populations (e.g., animals, people, grains of sand). Use sampling techniques. PE, OE, P
- Explain to a classmate the meaning of $3^0$. OE, P
- Find the pattern of the decimal equivalents for all fractions with a denominator of 9. Then extend to include fractions with a denominator of 99. Present findings using computer graphics. OE, P
- Represent, using models, a number as a fraction, decimal, and percent (e.g., 15/100 = 3/20, .15, 15%). Identify situations where one representation is more appropriate than another. PE, OE

## *Applications Across the Curriculum*

**Language Arts**
- Design a poster for recruiting students into higher level mathematics courses. PE, OE

**Science**
- Use Avogadro's number to determine the depth of a layer of marshmellows spread evenly across the United States. Identify factors which would influence a variation in the depth. PE, OE, P
- Use fractals in the creation of a topographic map. PE, OE, P

**Social Studies**
- Make predictions about the population, natural resources, wealth, and standard of living of different countries for the year 2025. PE, OE, P

**Arts and Humanities**
- Create a painting using a limited color scheme that has asymmetrical balance. Write an equation that demonstrates your solution. PE

**Practical Living**
- Complete a comparative study of the distance runners at the local high school. Do one study in miles, the other in meters. PE, P
- Display information on cardiovascular disease and lifestyle behavior so that it is readily understood. PE, OE, P

**Vocational Education**
- Estimate and determine the open mesh in a 60xx screen for screen printing. P

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.8: Students understand various mathematical procedures and use them appropriately and accurately.

**Learning Links:** Spreadsheets / Advertisements / Shopping / Computer Programming / Timeshare / Travel Plans / Networks / Flowcharts / Ecology / Pay Schedules / Income Tax / Universal Law / Scientific Principles / Law

**Related Concepts:** Mathematical Expression / Mental Mathematics / Technology / Logic / Estimation / Proportion / Computational Algorithms / Development of Algebraic Processes / Proof / Order of Operations

***Elementary Demonstrators*** 

***Middle School Demonstrators*** 

***High School Demonstrators*** 

Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Explore logical thinking strategies.
- Explore the use of open sentences to express real-life situations.
- Investigate and discover a variety of mental computation and estimation techniques.
- Translate concrete and pictorial problem situations into mathematical language and symbols, and vice versa.
- Investigate relationships through the use of patterns to construct operations and algorithms.
- Manipulate objects to model and communicate operations in a rich variety of problems.
- Apply and justify computational methods (calculator, paper/pencil, mental math, estimation, computer).
- Solve equations with concrete, pictorial, and abstract methods.
- Translate real-world proportional relationships into mathematical expressions and vice versa.
- Translate from concrete, pictorial, and verbal expressions to mathematical expressions and vice versa.
- Interpret and organize information for logical deductions.
- Use models and investigations to construct algorithms using rational numbers.
- Validate mathematical assertions and judge the validity of real-world statements using deductive arguments.
- Make and test conjectures through investigations.
- Select and apply appropriate strategies (e.g., equations, inequalities, matrices, and networks) to solve problems.
- Use concrete, pictorial, and abstract models to develop and/or solve algebraic problems.
- Use concrete, pictorial, and abstract models to develop and/or generalize a procedure.
- Formulate examples and counterexamples.

## Sample Teaching/Assessment Strategies:

**Collaborative Process**: Cooperative Learning, Peer Tutoring • **Graphic Organizers**: Matrix • **Problem Solving**: Heuristics, Future Problem Solving, Research, Formulating Models • **Technology/Tools**: Manipulatives, Computers, Games, Calculators

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Work with local social services representatives to compile data and determine average number of homeless who are fed in the community and plan low-cost nutritious meals for them.
- Prepare income tax returns for senior citizens.
- Serve as interns in local projects with civil engineer.
- Survey a variety of white and blue collar workers to determine if and how mathematics is used in their vocations.

# Core Concept: Mathematical Procedures

## *Sample Elementary Activities*

- Use a storyboard to model the action in a number sentence. PE, OE, P
- Compare the strategies in computer software programs which address logical thinking (e.g., Gertrude's Puzzles, Moptown Parade, Iggy's Gnees, The Pond, or Gnees or Not Gnees). PE
- Use a ten-frame chart to show various strategies for adding 9+8 (e.g. shift to make 10, doubles + 1, neighbors). PE, OE
- Use a calculator with a constant function to explore counting and operational patterns. OE
- Show how to divide different groups of items such as 5 candy bars, 10 donuts, or 11 comic books among 4 students. PE
- Create algorithms for adding, subtracting, multiplying, and dividing whole numbers. OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Sort out the jumbled pieces in an action sequence and list them in order. PE
- Locate a poem or story that shows a mathematical sequence. OE

**Science**
- Determine, calculate, and demonstrate the mechanical advantage of a pulley system or inclined plane. PE, OE, P

**Social Studies**
- Investigate time zones throughout the world. Calculate current time in countries/cities in the daily news (e.g., London, Tokyo, New York). PE

**Practical Living**
- Keep a log documenting regular participation in a physical fitness activity and graph time spent on your fitness program (e.g., jogging, bicycling, etc.). PE, OE, P
- Estimate and verify the total amount of trash in the school for a day. Graph results. PE, OE, P

**Vocational Education**
- Compose real-world problems using information from the newspaper or almanac (e.g., "What are the factors that affect milk prices?"). OE
- Compare the price of a cafeteria lunch versus a brown-bag lunch. Consider additional factors. PE, OE, P

# Core Concept: Mathematical Procedures

## *Sample Middle School Activities*

- Write a set of directions for a younger student, explaining how to add two fractions (e.g., 2/3 + 1/4). Use computer graphics to draw pictures or diagrams in the explanation. PE, OE, P
- Tell a story based on a selected picture that generates a multi-step mathematical problem. OE
- Investigate the Fibonacci sequence as applied to nature (e.g., seeds in a sunflower, whorls on a pineapple, birth of rabbits). Present findings using multimedia. PE, OE, P
- Verify the theorem: The sum of the angles of a triangle is 180 degrees. Cut a triangle out of a piece of paper. Tear off the corners of the triangle and assemble them in a straight angle. Or, fold a paper triangle so that the vertices meet at a point. P
- Compare the answers of a multi-operational exercise using paper/pencil and various brands of calculators. Determine the necessity for order of operations (e.g., 2+3x5 on some calculators equals 25, rather than the correct answer of 17). PE, OE, P

## *Applications Across the Curriculum*

### Variations on a theme: Commerce

**Language Arts**
- Use ads from newspapers to figure out the savings on sale items. Compare similar products and justify the selection of the best buy. OE, P

**Science**
- Estimate the cost of gasoline for the average driver over a one-year period. Reevaluate estimation if there were an additional 10 cents increase per gallon. Discuss impact of increase on a fixed salary. OE, P

**Social Studies**
- Track the change in the cost of a single item over an extended period. Calculate the cost of the item in a foreign currency using the current rate of exchange. OE

**Arts and Humanities**
- Trace the value of a work of art from the time it was created through each sale. OE

**Practical Living**
- Calculate the cost of smoking a pack of cigarettes a day for one week, one month, and one year. OE

**Vocational Education**
- Establish and maintain a classroom bank. PE

## *Reflections*

*Mathematical procedures are routines or processes that have predictable results. Computational methods, use of terms and formulas, and noncomputational processes, such as geometric construction, measuring, solving equations, and transformations are all included within mathematical procedure.*

*Emphasis of instruction on procedures should be on investigation and modeling using manipulatives to construct meaning. Students should build connections among concrete representations, pictorial representations and symbols, before practicing procedures or searching for patterns within the symbol system. They should eventually be able to extend or modify familiar procedures or algorithms and generate new ones. It is assumed that all students have access to calculators and computers as tools for all experiences with procedures.*

*As students apply mathematics, they will have to decide which algorithms or procedure to use, the sequence in which to perform them, and how to verify that they give correct answers. They also must understand concepts underlying a procedure and the logic that justifies it. Reflecting on how and why procedures work as they do leads to an appreciation of the nature and role of procedures in mathematics.*

*Sources: National Council of Teachers of Mathematics (NCTM), Curriculum and Evaluation Standards*
*James Hiebert, "The Role of Routine Procedures in the Development of Mathematical Competence,"*
*1990 NCTM Yearbook, Teaching and Learning Mathematics in the 1990s*

# Core Concept: Mathematical Procedures

## *Sample High School Activities*

- Explain the appropriate strategy to determine how many ways there are to travel among three points in a city using a series of one-way streets. Also consider the number of ways to travel from one point to another using one stopover. Use graph theory and matrices. P
- Obtain data of beginning and ending inventory from a local department store for a month including profit and sales commission. Use matrix operations to determine the number of items sold, profits, and commissions earned. Display data using spreadsheets. PE, P
- Solve an algebraic equation using algebra tiles, pictures of tiles, progressing to algebraic symbolism. PE
- Analyze advertisements for "if-then" statements embedded within them. Present findings using multimedia. PE, P
- Investigate perimeters of various rectangles with area of 24 square cm using models and drawings. Generalize to answer such problems as "Is there a rectangle of minimum perimeter with specified area?" Give dimensions. OE, P
- Design an algorithm to solve a difficult equation by using approximations. OE, P
- Design a method to approximate the area between two curves. OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Solve word problems by ordering the sequence of steps needed to complete the problem. Create a flowchart to match the steps. OE
- Create a database of words that have double meanings, one specific to mathematics and the other in another area (e.g., root, square). PE, P

**Science**
- Using a spreadsheet which incorporates birth, death, immigration, and emigration rates, predict the population of the United States at five year intervals over the next 25 years. PE, P
- Design an experiment to investigate a scientific principle such as Boyle's Law. PE, OE, P

**Social Studies**
- Investigate insurance actuarial charts to determine how insurance rates in the United States are established. Research the same information in another country. PE, P

**Arts and Humanities**
- Cut a matte of given dimensions for a picture. PE

**Practical Living**
- Research the incidence of HIV infection in United States population. Choose a factor (e.g., age, place of residence, number of partners) and calculate the risk of infection. OE, P

**Vocational Education**
- Prepare a spreadsheet comparing grocery brands for price, nutritional value, and convenience. PE
- Calculate cost of setting up a medical, dental, or other health care practice, including malpractice insurance and other costs. OE

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.9: Students understand space and dimensionality concepts and use them appropriately and accurately.

**Learning Links:** Sonar / Quilting / Cartography / Interior Design / Archaeology / Architecture / Computer Graphics / Graphic Design / Perspective / Auto-CAD / Clothing Design / Radar/Air Traffic Control / Fractals / Solar Systems / Dance / Topographic Maps / Molecular Models

**Related Concepts:** Regular and Irregular Figures in Various Dimensions / Coordinate Systems / Geometry / Congruence / Symmetry / Spatial Visualization / Spatial Representation / Similarity / Orientator / Vectors / Fractals

***Elementary Demonstrators*** 

***Middle School Demonstrators*** 

***High School Demonstrators*** 

Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Describe relationships among points, lines, segments, and angles.
- Explore symmetry, translations (slides), reflections (flips), and rotations (turns).
- Translate 3-dimensional objects to 2-dimensional drawings and vice versa.
- Investigate and predict the results of combining, subdividing, and changing shapes.
- Extend and create geometric patterns using concrete and pictorial models and recognize their use in the real world.
- Explore, identify, and classify similar plane and solid figures in various orientations.
- Describe, model, draw, sort, classify, and compare shapes.
- Demonstrate the spatial relationship of two objects (e.g., inside/outside, between).
- Visualize different representations of 2 and 3-dimensional geometric figures.
- Explore, describe, and draw transformations.
- Investigate symmetry, similarity, and congruence using concrete models and drawing.
- Use a coordinate system to define and locate position.
- Use attributes to classify and analyze regular and irregular figures in 2 and 3 dimensions.
- Verify conjectures about geometric objects using deduction (van Hiele Level 3).
- Explore and investigate the dimensionality of fractal objects.
- Compare, contrast, and translate among synthetic, coordinate, and transformational geometry.
- Apply transformations and vectors to solve problems and represent physical phenomena.
- Represent and solve problem situations with geometric models and properties.
- Apply congruence and similarity relationships in real-world situations.
- Interpret and draw 3-dimensional figures.

## Sample Teaching/Assessment Strategies:

**Collaborative Process**: Cooperative Learning • **Community-Based Instruction**: Field Studies • **Graphic Organizers**: Graphic Representations • **Problem Solving**: Inquiry, Creative Problem Solving, Future Problem Solving, Formulating Models • **Technology/Tools**: Computers, Manipulatives, Multimedia, Video Production

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Visit the geological survey department in your community and observe how maps are made.
- Do a community field study led by a local architect/construction worker/carpenter. Identify geometric properties and shapes used in the construction of buildings.
- Invite a local quilt maker to discuss repetition of patterns. Create class designs.

# Core Concept: Space and Dimensionality

## *Sample Elementary Activities*

- Build 3-dimensional shapes using toothpicks and gum drops. Discuss the relationship between the line segments and angles. PE, P
- Fold paper cutouts of various shapes (e.g. geometric shapes, leaves, snowflakes) to discover lines of symmetry. PE
- Construct a building with cubes. Then draw the building from all views (front, top, back, right side, and left side) on graph paper. PE, P
- Create a large square using a geoboard. Subdivide the square into as many squares as possible and record the number of squares. PE
- Construct a regular or irregular polygon on a geoboard and let another student construct the congruent shape in a slide (translation), turn (rotation), or flip (reflection) on his/her geoboard. Extend to movements made by characters on Nintendo games (Super Mario Brothers, Tetris). PE, P
- Create a repeating pattern with pattern blocks to cover an area such as quilt square, wrapping paper, or wallpaper. PE
- Make as many shapes as possible with 2 tangram pieces, 3 pieces, 4 pieces, and up to 7 pieces. PE
- Explore the properties of a planar shape using measuring instruments and list as many as you can. PE, OE

## *Applications Across the Curriculum*

**Language Arts**
- Describe the rotation of an object. OE, P
- Tell a story about what life might be like if there were only two dimensions. OE, P

**Science**
- Construct a scale model of an organism. PE
- Build or draw a model of the entire shell of an animal after observing a shell fragment. OE

**Social Studies**
- Find examples of familiar geometric shapes in the built/physical environment. Create a histogram showing the frequency in which shapes occur. PE, OE

**Arts and Humanities**
- Use triangle pieces to construct a design with a repeating pattern. Use markers to find new triangles created by overlapping. PE, OE

**Practical Living**
- Construct environmental mobiles using geometric shapes to depict recyclable items, conservation practices, and pollution control. PE

**Vocational Education**
- Rearrange furniture in a playhouse to be used by different numbers of children. PE
- Create a floor design with parquet blocks. PE

# Core Concept: Space and Dimensionality

## *Sample Middle School Activities*

- Construct models of the five platonic solids and investigate relationships among the numbers of edges, faces, and vertices. PE, P
- Draw 2-dimensional top, front, and side views to represent a 3-dimensional object. Reverse the process to draw a 3-dimensional representation based on top, side, and front views. Use isometric dot paper. PE, P
- Draw or build a 2 or 3-dimensional model using oral or written instructions provided by another student. OE
- Work in cooperative groups with school cameras to take a series of photographs as the photographer rotates 360°. Shuffle photos. Have other groups reassemble photos in order and locate position of photographer. PE, P
- Draw a portion of a map on graph paper, locate two points, X and Y, and write a set of directions from Point X to Point Y. PE, P
- Build a simple kaleidoscope to show rotations and reflections. PE, P
- Draw a checkerboard from both 1- and 2-point perspective. PE, P
- Design a tile floor or quilt using simple tessellations. PE, P
- Show that lines are parallel by synthetic geometry (congruent alternate interior angles) and coordinate geometry (equal slopes). Write a comparison of the two methods. OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Keep a "geometry journal." Cut out interesting shapes and designs and list places they might be found in the real world. P

**Science**
- Compare and contrast geometric shapes of crystal forms grown in the classroom such as salt, alum, and sugar. PE, P

**Social Stucies**
- Construct a model of an invention which would make a positive contribution to the American economy. PE, OE, P
- Develop a variety of maps depicting the school grounds (e.g., political, 3-dimensional relief map). PE, P

**Arts and Humanities**
- Draw your school building using 2-point perspective. PE, P

**Practical Living**
- Design a student activity area to best utilize existing areas. OE, P
- Enlarge a diagram of the body system using a grid method (physical wellness). OE

**Vocational Education**
- Draw a topographic map of a sloping area. PE, P
- Use a computer graphics program to design a brochure or invitation. PE, P

# Core Concept: Space and Dimensionality

## *Sample High School Activities*

- Estimate the height of the school flagpole using similar triangles, the height of a student, and relative lengths of shadows. PE
- Use vector analysis to determine the effect of wind shear on an airplane's actual track over ground. OE, P
- Design a computer program to draw a fractal. Use design on a T-shirt. PE, P
- Construct an Escher-type tessellation. PE
- Build a prism using cubes and find the surface area. Rearrange the same set of cubes into another shape and find the surface area. Discuss reasons why one shape could be more economical to build than another. PE
- Draw a coordinate system on a parking lot or football field; assign all students a different x value; students stand along the x-axis, and teacher calls out an equation in y-intercept form; students walk to y value to represent the graph. PE

## *Applications Across the Curriculum*

### Variations on a theme: Sculpture

**Language Arts**
- Describe a famous piece of statuary in terms of space and dimensionality. PE, OE, P

**Science**
- Design a packaging system to transport a particularly fragile sculpture. PE, P

**Social Studies**
- Trace the historical development of representations of the human form in sculpture with regard to size and proportion. P

**Arts and Humanities**
- Create a sculpture from a 2-dimensional subject. PE, P

**Practical Living**
- Design a display for a variety of sculptures. PE, P

**Vocational Education**
- Design a sculpture garden. PE

## *Reflections*

*Students who put a jigsaw puzzle together with ease, follow the drawing for the bicycle assembly, create three-dimensional models in geometry class, and read a road map without turning it upside down, are the students who are adept in the visual/spatial intelligence, understand dimension, and enjoy solid geometry. Yet, all students need to develop these skills in space and dimensionality if they are to be grounded in such practical arenas as interior design, dance, graphic arts, and architecture.*

*This area of mathematics helps students make the transition from abstract to concrete. Through investigative techniques that integrate art, design, and computer technology, students can apply the inert knowledge of the textbook to practical, real-life situations.*

*There are unending opportunities to incorporate the concepts of space and dimension into motivating and meaningful classroom projects. This planning is facilitated when an interdisciplinary team of experts lends insight into relevant learning experiences.*

*Sources: British Columbia Ministry of Education, Vocational Education/Integrated Learning*
*National Council of Teachers of Mathematics, Curriculum and Evaluation Standards*

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.10: Students understand measurement concepts and use measurement appropriately and accurately.

**Learning Links:** Biorhythms / Circular Motion / Sound Waves / Scale Drawing / Light / Recipes / Sewing / Electricity / Drafting / Unit Pricing / Construction / Sports / Meteorology / Latitude and Longitude / Seismograph

**Related Concepts:** Maximum/Minimum / Trigonometry / Perimeter / Nonstandard Units / Area / Mass / Time / Metric/ Customary Units / Volume / Angle / Money / Vectors / Dimensions / Weight / Rate / Temperature / Area Bounded by a Curve

***Elementary Demonstrators***

***Middle School Demonstrators***

***High School Demonstrators***

Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Make estimates and measurements in solving problems using appropriate tools and units.
- Use nonstandard and standard units of measure.
- Develop concepts of length, capacity, weight, mass, area, perimeter, volume, time, temperature, angle, circumference, and money through use of manipulatives.
- Compare and order mass, length, area, and volume.
- Conserve mass, length, area, and volume.
- Develop, through investigation, the formulas for perimeter, area, and volume.
- Determine the area of irregular shapes by subdivision using manipulatives.
- Extend the concepts of length, area, volume, mass, weight, capacity, time, angle, perimeter, money, circumference, and temperature using measurement tools and models.
- Investigate the concepts of rates, energy, and other derived and indirect measurements.
- Explore periodic real world phenomena.
- Apply trigonometry to real world problems.
- Determine surface areas and volumes of solids in solving nonroutine real world problems.

## Sample Teaching/Assessment Strategies:

**Collaborative Process**: Cooperative Learning, Peer Tutoring • **Community-Based Instruction**: Field Studies, Mentoring, Service Learning • **Problem Solving**: Brainstorming, Inquiry, Formulating Models, Future Problem Solving, Research • **Technology/Tools**: Manipulatives, Computers, Video Production

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Interview building contractors to explain measurement as it applies to construction and cost.
- Observe and record the ways measurement is used by employees during a visit to a medical laboratory (e.g., T-waves on an EKG, or number of blood cells on a blood smear).
- Visit an amusement park to investigate application of laws of physics on various rides.

# Core Concept: Measurement

## *Sample Elementary Activities*

- Plan and plant a class garden on school grounds. Use seed charts to determine distance between plants. Plot temperature and rainfall each day. PE, P
- Measure a tabletop perimeter to the nearest decimeter and centimeter. Evaluate which measurement is more appropriate. PE, OE
- Estimate the number of large pizza boxes required to cover the playground, and determine a method to evaluate your estimate. PE, OE, P
- Order a group of objects by estimation of their weights. Use a balance scale to determine the actual order and compare predictions. PE
- Pour the same amount of liquid into two identical containers. Pour the contents of one container into a third container of different shape/size. Determine whether the containers hold equal amounts (conservation activity). PE

## *Applications Across the Curriculum*

### Variations on a theme: Sports

**Language Arts**
- Write and illustrate a book about how measurement is important in your favorite sport. PE, P

**Science**
- Prepare graphs to compare the areas of various sports fields relative to the number of players. PE, OE, P

**Social Studies**
- Investigate the influence of geography of a region on the development of sports playing fields. OE, P

**Arts and Humanities**
- Design a one-size T-shirt for your classmates to wear as a sports uniform. Determine if the average size is appropriate for all. Create a logo for the uniform. OE, P

**Practical Living**
- Develop a school-wide Olympics in which all students will participate. PE

**Vocational Education**
- Create a database to display information about sports injuries in children ages 5-18. Include gender, age, and sport. Show frequencies and correlations using computer-generated graphics. OE, P

## *Reflections*

*Measuring requires not only skill in using various measurement tools, but also the conceptual understanding of establishing and using a standard to analyze information. Currency is set on a standard, for example, as is weight, volume, area, length, and temperature.*

*By introducing traditionally accepted standards such as metric, and helping students invent their own set of standards, skillful use of the measurement tools is undergirded with in-depth understanding of why standards are needed and how they work.*

*As students become skilled in the use of the various measurement tools, problem-based learning situations can focus attention on how to select the most appropriate measuring device and how to best analyze the information. Because communication skills relate to other skills of research and reporting, teachers can integrate appropriate measuring activities and subsequent discussions about measurement into many relevant areas of classroom investigation.*

*Source: National Council of Teachers of Mathematics (NCTM), Curriculum and Evaluation Standards*

# Core Concept: Measurement

## *Sample Middle School Activities*

- Select a shape to represent one unit of area measurement. Use the unit to find the area of irregular figures (e.g., geoboards, grid paper, dot paper). PE, OE
- Demonstrate experimentally the volume of a cone compared to the volume of a cylinder with the same base and height. PE, P
- Use and explain three different methods for approximating the area of an irregular shaped playground. PE, OE, P
- Use similar figures or the Pythagorean Theorem to make indirect measurements (e.g., shadows, pinhole cameras). P
- Investigate the average number of kernels on an ear of corn. Compare findings with number of kernels found in the average serving of canned corn/popped corn. PE, OE, P
- Use a trundle wheel to investigate circumference and its relationship to $\pi$ by connecting one end of a string to a stake in the center and the other end to the axle support of the wheel. Compare the circumference of the circular path to the radius using various lengths of string. Record and explain results. PE, P

## *Applications Across the Curriculum*

**Language Arts**
- Write an explanation to this question, "If you measured an object with five different methods and got five different answers, how would you decide which answer is correct?" OE

**Science**
- Calculate the time it takes for light to reach the earth from the sun and the next nearest star given the distances involved. OE
- Calculate the average density of several types of stones. OE

**Social Studies**
- Pretend it is the mid-1800s. Research and share how measurement was important to the following professions: sailor, physician, explorer, and farmer. OE
- Research standards of measurement such as clothing and shoe sizes. What differences would you encounter if there were not "standards"? OE

**Arts and Humanities**
- Find the number of ways a piece of paper can be divided into two equal areas. OE

**Practical Living**
- Make a scale drawing of a classroom which depicts energy conservation measures. PE
- Prepare a recipe that includes using a variety of measuring techniques (e.g., liquid, dry, volume, length). PE

**Vocational Education**
- Estimate actual dimensions of a house given a 3-dimensional model with 1 inch representing 1 foot. Create a scale drawing. PE, OE, P

# Core Concept: Measurement

## *Sample High School Activities*

- Measure the length of the parking lot at your school. Use a stopwatch to measure the time it takes to walk this distance. Compute walking speed . PE
- Determine the maximum volume of a container formed by cutting squares from the corners of grid paper and folding to make a box. Use models, charts, and graphs of the function to determine the maximum measurement. PE, P
- Estimate the area between two curves. Use a graphing calculator to adjust your estimate. OE, P
- Investigate the relationship between the observation of a flash of lightening and a clap of thunder. Use the information to determine the location of the greatest electrical activity. PE, OE, P

## *Applications Across the Curriculum*

**Language Arts**
- Write and illustrate a book for children about a character who had no measuring tools. P

**Science**
- Use a laser to generate data to mathematically calculate the distance a student moves a wall using hand pressure. PE
- Develop an activity, to be used in a middle school classroom, to teach the concept of parallax. PE, OE, P

**Social Studies**
- Prepare a map of school grounds using an accurate measurement key. PE, P

**Arts and Humanities**
- Create a sculpture of a human head (self-portrait) using tools (calipers) to obtain and transcribe actual measurements. PE, OE, P

**Practical Living**
- Calculate and record the effect of different types of exercise on the heart rate. PE, P
- Determine the amount and cost of carpet and wallpaper needed to decorate an office. PE, OE, P

**Vocational Education**
- Measure the P-waves, QRS complexes, and T-waves on an EKG. Analyze the results. PE, OE, P

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.11: Students understand mathematical change concepts and use them appropriately and accurately.

**Learning Links:** Nature / Evolution / Chaos / Topology / Human Development / Mutations / Chemical Reactions / Geopolitical / Fractals / Rock Formations / Migration

**Related Concepts:** Transformations / Trigonometric Functions / Continuous vs. Discrete / Algebraic Representations/ Variables / Limit / Sequences / Functions / Matrix Representations / Series / Patterns

***Elementary Demonstrators*** 

***Middle School Demonstrators*** 

***High School Demonstrators*** 

Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Use variables, represented by manipulatives, to express relationships involving change.
- Explore the concepts of unknown quantities and effects of change (functions).
- Extend and create patterns and generalize structures from patterns (e.g., square numbers, geometric patterns, patterns in nature) in number sequences.
- Observe patterns of change (e.g., seasons, height, weather) in everyday life and discuss causes and effects.
- Explore functions that can be derived from physical models, data, and other mathematical representations.
- Investigate patterns in number sequences and relate to real world experiences.
- Represent patterns in several ways (e.g., graphs, ordered pairs, verbal statements, algebraic rules).
- Investigate the properties of various types of functions, (e.g., linear, quadratic, logarithmic, trigonometric, etc.).
- Determine appropriate model to represent change in data (i.e., discrete or continuous).
- Use curve fitting to predict change.
- Explain how a change in one quantity affects a change in another.
- Model a variety of problem situations with similar functions.
- Analyze the effects of parametric changes on graphs.

## Sample Teaching/Assessment Strategies:

**Collaborative Process**: Cooperative Learning • **Community-Based Instruction**: Mentoring • **Continuous Progress Assessment**: Observation, Performance Events, Portfolio Development • **Graphic Organizers**: Graphic Representations, Flowchart • **Problem Solving**: Inquiry, Questioning, Case Studies, Creative Problem Solving, Future Problem Solving, Formulating Models, Simulations • **Technology/Tools**: Manipulatives, Computers, Multimedia

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Contact public agencies for data specific to the community (e.g., water company for information on water pressure and flow rate, U.S. Census Bureau for demographic data).
- Take a field trip to the local automobile dealership and have a salesperson explain how the NADA (Blue Book) standards are used to determine the price of used cars.
- Survey businesses to discover how future sales/services are projected from current sales figures and how that affects future staffing.

# Core Concept: Change

## *Sample Elementary Activities*

- Use a working set of interlocking gears with 24, 12, 8, and 4 teeth, and predict the number of revolutions for each. Use the computer program "Gears" for a follow-up program. PE, P
- Read "Caps for Sale." Use a simple spreadsheet program to calculate money received if a variable number of caps are sold at $.50 a cap. OE
- Use a calculator with a constant to play "What's My Rule." Enter "+4=" to store. Press "4 =" (the number 8 will show). Give to partner, who presses a number and "=" to determine the rule (the number that is stored). OE
- Place one bean plant in sunlight, and another bean plant of the same size in a closet. After one week, measure both, record the changes and discuss the reasons for any differences. PE, OE
- Build 2, 3, and 5 span bridges using red and yellow Cuisenaire rods (1 yellow and 2 end red rods = 1 span). Explain how many red and yellow rods you would use to make a 20 span bridge. Develop a rule for building bridges. PE, OE, P
- Describe patterns found on addition, subtraction, multiplication, and division tables. OE
- Describe patterns on a hundreds chart. OE

## *Applications Across the Curriculum*

**Language Arts**
- Write a recipe book, including measurements, for enlarging or reducing the recipes. P

**Science**
- Create a collage time line of science-related toys over a period of fifty years. P
- Construct flip-books of the life cycle of a plant (bean) or animal (butterfly). OE

**Social Studies**
- Select a popular vacation spot. Predict seasonal or event related population changes. Gather data that supports or rejects the prediction. Present findings using graphic representatives. OE, P

**Arts and Humanities**
- Make a value scale using black and white tempera paint. Record the value changes by amount of white paint added. OE, P

**Practical Living**
- Record height and weight of students over time. Do a chart comparison from the beginning, middle, and end of the year. P

**Vocational Education**
- Calculate the number of cups of ice required to meet the Recommended Daily Allowance (RDA) of water. P

# Core Concept: change

## *Sample Middle School Activities*

- Discuss the effect of coordinate changes on the shape of coordinate plot pictures ( e.g., double both x and y coordinates and plot a new picture, double the x values and plot a new picture). PE, P
- Show graphically how overhead costs and expenditures for advertising affect profits of a pizza parlor. PE, OE
- Investigate relationships between height and length of radius bone of several students in the class. Develop a general rule. Suppose you are an anthropologist and have found a radius bone of 25 cm. long. Predict the height of the person. PE, P
- Use the school records from 20 and 10 years ago to determine the most popular first names of boys and girls. Survey the current school population to find the current top ten. Based on past trends, predict the ten most popular names for boys and for girls in the year 2000. P

## *Applications Across the Curriculum*

### Variations on a theme: Pollution and the Environment

**Language Arts**
- Research waste management control practices for public schools. Present your findings to the school council, school board or other decision-making body. PE, OE, P

**Science**
- Track the amount of paper or food-scrap waste in the school over specific periods of time. Graph the results. P

**Social Studies**
- As a group project, design a campaign to address waste management issues and convince classmates, teachers, administrators and staff to become involved with a waste reduction program at the school. PE, P

**Arts and Humanities**
- Inform people through a visual medium about the waste management compaign project and encourage continued involvement. PE

**Practical Living**
- Prepare a set of suggestions for reducing the amount of food-scraps and packaging waste. Graph results of the reduction in waste. OE, P

**Vocational Education**
- Investigate and present data showing the growth in waste management careers over the last decade. PE, P

## *Reflections*

*Students need opportunities to study change in time, space, and events. The mathematics of change asks students to argue their understanding. This may require a model that allows for both interpolation and extrapolation. Such a demonstration of understanding should encourage reasoning in the area of "what might be" and "what if."*

*Using particular patterns in mathematics, students learn how change affects patterns or functions. In arithmetic, functions appear as operations on numbers; in algebra, as relationships between variables; in geometry, as relationships between points and their images under motions; in probability, as relationships between events and their likelihoods. Students need ways to discover functional relationships between two variables by observing a phenomenon and by gathering and plotting observational data. They can then represent the changes with graphs, algebraic equations, or verbal statements. Although change is introduced in mathematics and science areas, it is embedded in studies of history, literature, cultural arts, and technology.*

*Source: National Council of Teachers of Mathematics (NCTM), Curriculum and Evaluation Standards*

# Core Concept: Change

## *Sample High School Activities*

- Collect data on a particular car model from the NADA book (Blue Book ). Plot the year (independent variable) with the price (dependent variable). Look for patterns. Compare different models. PE, P
- Investigate and compare graphs of families of functions using a graphing calculator. PE, P
- Discuss and act out a story based on interpretation of a graph of a traveling vehicle. PE, OE
- Use technology to graph the following situation: A ball is dropped from a height of 10 meters and loses 30% of its height (y) on each successive bounce (x). The maximum height on each bounce is given by $y=10(0.7)x$ where x must be a positive integer. Compare this discrete graph to a continuous graph of the same equation where the domain is the set of reals. Discuss why a discrete graph (rather than a continuous graph) is the appropriate representation of this situation. OE, P
- Explain how changing the parameters of a function affects the graph of a function, e.g., how does f(x) differ from f(x+a) and from f(bx). OE
- Create a large right triangle on the floor using a large loop of string with student at each vertex. Investigate sine and cosine relationships by changing the angle at the center (maintain constant length of the hypotenuse). Follow up with use of scientific calculator. PE

## *Applications Across the Curriculum*

**Language Arts**
- Write a valid argument to convince someone that adding the same number of points to each student's test score will increase the average score by the same amount. OE, P

**Science**
- Collect and graph pressure and volume data. Develop an equation relating pressure to volume. PE, OE, P

**Social Studies**
- Research the changes in the types and numbers of crime occurring since 1800. Draw conclusions as to why changes have occurred and make predictions for changes in the future. OE, P

**Arts and Humanities**
- Write an essay describing how color changes and relationships influence color clarity, setting, and mood. PE, OE, P
- Choose a well known artist's work (e.g., Starry Night, Whistler's Mother ). Reproduce the painting using opposite colors from the artist. P

**Practical Living**
- Calculate the average number of times people change jobs in the United States. Infer the consequences for your education as you prepare for a career. P

**Vocational Education**
- Contrast the root-growth rate of plants that have a 5.0 pH and those that have a 7.0 pH. PE, P
- Set up a graphical representation of an insurance actuarial table using spreadsheet software. PE, P

# Goal 2: Apply Core Concepts and Principles

## Academic Expectation 2.12: Students understand mathematical structure concepts including the properties and logic of various mathematical systems.

**Learning Links:** Anatomy / Programming / Cause-and-Effect / Outline/Research / Mayan/Incan/Aztec/Egyptian Cultures / DNA / Binary Systems / Political Systems / Cryptology / Government

**Related Concepts:** Logic / Systems of Equations / Discrete Structures / Number Systems / Order Relations / Inequalities / Patterns / Matrices / Axiomatic Systems / Properties (Fields)

***Elementary Demonstrators*** 

***Middle School Demonstrators*** 

***High School Demonstrators*** 

Demonstrators should be read from bottom to top, but need not be demonstrated sequentially.

- Compare and contrast the structural characteristics of varying numeration systems (e.g., other bases, Roman numerals, cuneiform).
- Explore logical thinking (i.e., analogies and syllogisms).
- Explore the properties of relations, including order (i.e., <, >, familial relationships, longer than).
- Sort objects and compare attributes.
- Use and compare various number systems.
- Communicate (by modeling, verbal/written explanation, and graphing on a number line) an understanding of order relations and inequalities.
- Apply field properties to solve problems and equations (e.g., pencil/paper and mentally).
- Use order of operations with rational numbers.
- Use deduction in an axiomatic system.
- Analyze similarities in various mathematical systems.
- Communicate the logic of algebraic procedures.
- Analyze the structural characteristics of the real number system and various subsystems.
- Investigate and solve optimization problems.

## Sample Teaching/Assessment Strategies:

**Graphic Organizers:** Compare/Contrast Structures, Mapping, Matrix • **Problem Solving:** Heuristics, Inquiry, Debate, Oral History • **Technology/Tools:** Calculators, Computers, Games, Manipulatives

These sample strategies offer ideas and are not meant to limit teacher resourcefulness. More strategies are found in the resource section.

## *Ideas for Incorporating Community Resources:*

- Invite a variety of ethnic representatives in the community to bring the class samples of their number systems.
- Examine, with a local architect, buildings in the community that illustrate the "Golden Rectangle."
- Interview police, attorneys, and physicians on the effect of using DNA for identification in criminal cases.

# Core Concept: Mathematical Structure

## *Sample Elementary Activities*

- Study the culture of Egypt; describe and compare the use of Egyptian and Hindu-Arabic (ours) numerals. P
- Solve and create analogies: a. inch: yard:: centimeter: __METER__ ;
  b. ball: circle:: __BOX__ : rectangle P
- Examine the Fibonacci numbers and find examples in nature (petals on a flower, birthrate of rabbits, spirals on a pine cone). OE, P
- Prepare a graphic organizer (web) of your family. In a cooperative group, each student assumes the role of a specified family member. Each student explains his/her relationship to other members of the group. OE, P
- Stand in hula hoops (Venn diagram) according to assigned attributes, (e.g., red shirts in one hula hoop, blue tennis shoes in another hoop). PE
- Discuss when you might need to sort into given classes or subclasses. OE

## *Applications Across the Curriculum*

**Language Arts**
- Write directions to enter a mathematical expression into a calculator. PE, P

**Science**
- Determine the surface area of different leaf specimens by using grids or geoboards. Sequence the leaves based on the surface areas; graph the results. PE, OE, P

**Socal Studies**
- Develop a chart showing the relationship between the population of states and the number of votes in the electoral college. The chart should arrange states from largest to smallest in terms of population. OE

**Arts and Humanities**
- Photograph classmates to determine components of interesting pictures. OE, P

**Practical Living**
- Make a chart showing positions and responsibilities of players on a flag football team. OE

**Vocational Education**
- Conduct a food drive; sort collected food into food groups. Organize into nutritious meals. PE, OE

# Core Concept: Mathematical Structure

## *Sample Middle School Activities*

- Use models to compare the relative sizes of fractions and decimals (fraction bars, decimal factory, and/or decimal squares). OE
- Analyze problems to see how the field properties can simplify computations and practice using mental math strategies (e.g., 12(1/2 + 1/3) = 12x1/2 + 12x1/3 or 16+(84+59) = (16+84) + 59). OE
- Invent, develop, and explain a monetary system and put it into operation in the classroom. PE, PO
- Create a number puzzle that chains a starting number and ending number together using all four operations. OE, PE, P
- Illustrate a recent homework problem using a flowchart. PE

## *Applications Across the Curriculum*

**Language Arts**
- Write a story to describe an algebraic equation. Use names of class members and familiar situations. OE, P

**Science**
- Compare the surface area available for photosynthesis on a variety of leaves and needles and make correlations with the total number leaves on the tree. PE, OE, P
- Determine the gene frequency of a trait in your classroom population. P

**Social Studies**
- Chart the passage of a bill through Congress. PE, OE, P

**Arts and Humanities**
- Use a formal structure to notate "Jingle Bells." PE, OE, P

**Practical Living**
- Use a computer program to chart the individual intake of minerals and vitamins for one day. Relate to the RDA (required daily allowance). OE, P

**Vocational Education**
- Compute the time it will take an accident victim to rebuild a given blood loss. OE, P