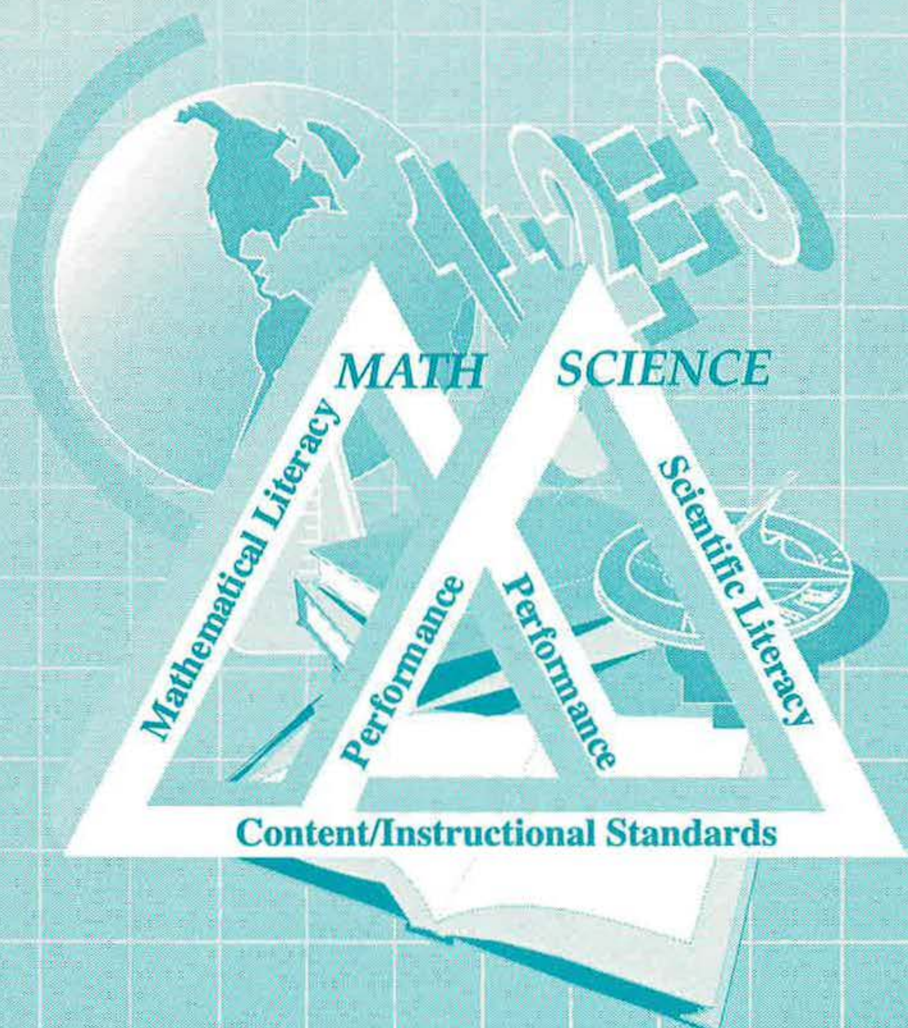


# Addendum to the Nebraska Mathematics & Science Frameworks

# Addendum to the

# Nebraska Mathematics/Science Frameworks

# Additional Acknowledgments

Numerous individuals representing teachers, teacher educators, learning psychologists, curriculum developers, subject-matter supervisors, school administrators, parents, and citizens have provided input to create a useful document for Nebraska.

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# Assessment

A look into a classroom may reveal a teacher teaching to the test, students interested in learning what will be on the test, and administrators gauging progress from test results. In the past, testing has been the primary means of assessment.

Test results serve a variety of functions including student ranking and placement. Often instruction has been designed to match the test. Educators must broaden their concept of assessment to go beyond testing, to include thought-provoking questions and problems so that assessment becomes a part of the instructional process.

Traditionally, instruction and assessment have been separate entities. Assessment must be an integral part of instruction and learning so that it is used as a tool to influence instruction. This requires developing and implementing assessment strategies that measure students' performance on tasks that emphasize the ability to think critically, to demonstrate a real understanding of concepts studied, and to apply what one knows to the kinds of complex problems encountered in life.

The national mathematics standards (National Council of Teachers of Mathematics) and national science standards (National Research Council) focus on conceptual understandings and analytical skills. This change in emphasis requires mathematics and science educators to examine current assessment practices. Assessment strategies need to be aligned with the vision of mathematics/science that engages all students in educational experiences that teach the nature and process of mathematics/science as well as the content. The unique nature of mathematics and science, especially hands-on experiences, requires a variety of assessment strategies.

## *What is Assessment?*

Assessment is a process used to monitor skills, check for depth of knowledge and understanding, and modify instruction. Discovering where students are and where they need to go is the purpose of a continuous, multidimensional assessment procedure. Assessment gives diagnostic information about what students have learned and can be used to improve educational programs. To be truly effective, assessment results must be communicated to students, parents, and other educators. Students need to receive assessment feedback and be given time and support to improve their own learning. The process of using assessment data to make judgments is called evaluation.

## *Types of Assessment Strategies*

Individual differences in students and in the way they learn mathematics/science requires assessing in a wide variety of ways to ensure that teachers accurately determine what the student is learning. Traditional modes of assessment such as pen/pencil tests may be used. Alternative means of assessment include authentic assessment and performance assessment.

Performance assessment strategy requires students to complete a task, create a product, or construct a response that demonstrates their knowledge of a skill, process, or concept. Rubrics or scoring guides provide students and teachers criteria with which to judge a performance assessment. Rubrics clarify for both students and teachers how process skills are being measured and help monitor skill development. See appendix for sample rubrics to assess the mathematics/science process skills of learning.

The authentic assessment strategy uses real-life situations and problems that are relevant to life outside of school. Teachers need to offer students "real" problems where students organize data, draw conclusions, and present possible solutions. These open-ended investigations may generate a number of acceptable solutions. This assessment strategy provides students with the opportunity to demonstrate conceptual understandings of the big ideas, to use process skills and tools, and to apply their understanding of these big ideas to solve new problems.

Paper/pencil assessment includes traditional end-of-the-unit/chapter tests, teacher-made tests, norm-referenced tests, and criterion-referenced tests. The criterion-referenced assessment strategies are designed to reveal what a student knows, understands, or can do in relation to specific criteria. Criterion-referenced assessments are required by the State of Nebraska to determine acquisition of competencies in reading, writing, and mathematics beginning in the fifth grade. A norm-referenced test compares a student's knowledge and skills to a group norm. Nebraska requires a norm-referenced test at least once at the upper elementary, middle school, and high school levels. Paper/pencil assessment provides important feedback useful in monitoring students' continuous progress.

## *Emerging Ideas in Assessment Techniques*

Students should know what they are to learn and how they will be expected to demonstrate that learning. Communicating goals and objectives provides students with reasons to learn. Specifying expectations and establishing criteria allow students to see where they are going and how they will know when they have gotten there. Adding criteria to teacher and student behaviors, such as communication, observation, and representation, have resulted in excellent assessment techniques.

Students' personal communication can give information about what they are thinking and understanding. Written tests offer one avenue for teachers to check for knowledge and understanding. However, providing problems and merely determining whether the answer is correct is insufficient. Teachers must assess the students' levels of understanding by looking at the processes and strategies used to find the correct solution. These processes and strategies can be shown in students' journals or learning logs. Journals or learning logs give students a chance to share their "Aha!" discoveries and understandings.

There are several other techniques which promote student communication and self-assessment. For instance, individual conferences allow time for students to ask questions that they may not ask in large group situations. Cooperative learning and small group discussions provide an avenue for personal communication, peer teaching, and assessing. Portfolios present an opportunity for the collecting of and reflecting on a student's work as well as enabling the student to make decisions about self-assessment. Communication between teacher and students in the form of open-ended questioning enables teachers to determine if students understand the problem, can organize and interpret information, are able to make generalizations, and clarify and express their own thinking. Thought-provoking questions challenge students to explore concepts and assist students to reach high expectations.

Teacher observations can supply much-needed information about student progress. In the past, teacher observations have been primarily informal and undocumented. When documented, teacher observation can provide insights into student abilities and understandings and help focus instruction. Checklists of specific skills and knowledge and systematic observations of student participation and class interactions contribute valuable assessment information. Rubrics which specify criteria of desired behaviors help to formalize the checklist.

There are many opportunities for students to demonstrate their knowledge and skills. These include experiments, written and oral reports, illustrations and graphing of information, debates or skits to portray information, projects, or multimedia presentations. These representation opportunities enable students to learn by doing, promote inquiry and problem solving, accommodate diverse student learning styles, stimulate student interest, and encourage creativity and inventiveness.

The alignment of curriculum, instruction, and assessment enhances learning for all students. The best assessment techniques are ones that not only monitor but enhance learning and instruction. The Nebraska Mathematics/Science Framework Project recommends that a variety of assessment techniques be used. Variations in assessments leads to a broader, more complete picture of the student's abilities and understandings. The following graphic organizer illustrates a variety of assessment techniques. Diverse assessment techniques can help teachers to understand a student's progress and design opportunities for future growth.

**ASSESSMENT TECHNIQUES**

- Representations
  - Illustrations
  - Video/Audio Tapes
  - Speeches
  - Experiments
  - Written\Oral Reports
  - Debates
  - Projects
- Observation and Perceptions
  - Classroom Interactions
  - Student Participation
  - Checklists
- Personal Communication
  - Learning Logs\Journals
  - Individual Conferences
  - Small Group Discussions
  - Portfolio
  - Questioning
  - Written Tests

## *Nebraska Mathematics/Science Frameworks Beliefs about Assessment*

The Nebraska Mathematics/Science Frameworks believes that assessment for all students should be:

- an integral, enriching part of learning and instruction.
- reflective of instructional goals.
- student-centered.
- considerate of individual needs and cultural influences.
- motivating, consistent, and non-threatening.
- offering multiple opportunities for success.
- collaborative.
- aimed toward the ultimate goal of self-assessment.

There are many valuable assessment techniques to measure student learning. A variety of techniques are exemplified in the mathematics/science instructional models found on pages L – 18 — L – 64.

# Connections

Connections must be made within mathematics and within science as well as across all disciplines. The following concept webs illustrate how a hands-on, student-centered activity can be used to connect the five core subjects included in Nebraska Department of Education Rule 10, process skills of learning, conceptual understandings, and the community.

The core subject areas of mathematics, science, social sciences, and language arts were selected from Nebraska Rule 10. For accreditation purposes, these core subject areas must be part of the instructional program at both the elementary and secondary levels.

The process skills of learning, promoted throughout the document, serve as tools for students to solve problems and inquire about the world in which they live. These skills are common to both mathematics and science and are used to emphasize the connection between the two disciplines. Many process skills of learning are used in the mathematics and science instructional models. Teachers need to focus on one or two skills during an activity. This provides the opportunity for teachers to facilitate student development of targeted skills. The process skills of learning are defined on page VIII-IX of the original document.

Throughout the document, concepts are developed in great depth while facts and terminology are de-emphasized. Content is addressed through student construction of "big ideas" or conceptual understandings. In creating the concept maps, the activity was the focus used to generate a multidisciplinary approach to learning. This approach enhances students' ability to fully comprehend the "big idea."

The school is a reflection of the community and is a collaborative responsibility of all stakeholders. The community is one of the best resources to help all students make connections to the real-world. Students need opportunities to apply mathematic and science knowledge and to make connections between what they learn in the classroom, in their everyday lives, and in the workplace. This results in students who are more motivated, who exhibit a more positive attitude about their school and community, and who become more involved in their community.

A concept web has been developed at each of the levels — elementary, middle, and secondary — to illustrate one method to develop multidisciplinary connections. The activities used to create the following webs are found on pages L – 27, L – 47, and L – 59 of the addendum. The webbing process can result in many individual and unique webs depending upon teacher knowledge, resources, student interest, and instructional objective.

## *Concept Web — Elementary Level*

### Big Idea:
Diversity

### Mathematics*
Estimate number of bugs caught
Count number of bugs caught
Write situation problems that reflect the number of bugs collected
Figure ratio and percentage of one type of insect to the total population
Graph results and analyze data

### Science*
Design a system to collect a variety of insects for scientific study
Classify insects
Design an insect to flourish in a specific environment
Complete lab that shows evidence of the scientific method

### Social Sciences*
Plot the migration paths of selected insects; e.g., killer bees, monarch butterflies
Investigate uses of insects by cultures throughout the world; e.g., food source, religious rites, medicine

### Activity:
**Bugs on a Stick**

### Language Arts*
Create bug books
Write lab report
Make journal entries
Write Poetry

### Community
Classroom visitors
- Pest controller
- Extension agent
- Bee keeper
- Entomologist
- Crop-dusting pilot

### Fine Arts
Create an insect out of various materials
Perform songs/music such as Goin' Buggy or Flight of the Bumble Bee
Prepare food such as Dirt Cups or Ants on a Log

### Reading
Read from the following: *The Icky Bug Counting Book* by Jerry Pallotta; *The Grouchy Lady Bug* by Eric Carle; *How Many Bugs in a Box* by David Carter; *The Very Quiet Cricket* by Eric Carle; *Old Black Fly* by Jim Aylesworth

### Process Skills:
Classification
Predicting
Hypothesizing
Observing
Interpreting Data
Problem Solving

*Included in Nebraska Rule 10

## *Concept Web — Middle Level*

### Big Idea:
Cells and Heredity
Algebraic Topics

### Mathematics*
Investigate volume of spheres
Analyze data and discover linear progression
Graph results
Interpret statistics

### Science*
Investigate lung capacity and the effects of variables
Compare lung capacity of smokers, non-smokers, and asthmatics
Debate the effects of second-hand smoke

### Social Sciences*
Discuss laws dealing with smoking
Investigate tobacco and its uses in various cultures
Discuss global acceptance and societal issues of smoking
Debate subsidies to tobacco farming

### Activity: **If You Smoke, You Croak**

### Language Arts*
Research diseases and/or second-hand smoke

### Community
Coordinate with DARE Program
Collect data on the effects of the anti-smoking campaign
Use community data to determine effects of exercise, smoking, age, and sex on lung capacity

### Reading

### Process Skills:
Communicating, Modeling, Interpreting Data, Questioning, Measuring, Reasoning

*Included in Nebraska Rule 10

## *Concept Web — Secondary Level*

### Big Idea:
Interdependence

### Mathematics*
Investigate surface area and volume of solids
Calculate ratios
Create geometric models

### Science*
Discuss adaptability to different environments
Explore characteristics of natural dwellings
Determine energy efficiency of dwellings
Explore relationship of surface area to phenomena

### Social Sciences*
Design dwellings for specific environments
Discuss historical dwellings

### Activity:
**Can-Can**

### Language Arts*
Write or give oral reports on container designs
Write packaging companies to communicate findings

### Community
Research consumer preferences and marketing techniques
Community leaders discuss construction or engineering as a career

### Reading
Cooperative groups research various environments and dwellings
Read and discuss *Loghouses in the Northwest USA*

### Process Skills:
Communicating, Predicting, Connecting, Problem Solving, Modeling, Reasoning

*Included in Nebraska Rule 10

# Inquiry/Problem Solving

Inquiry/problem-solving skills help students become critical thinkers, self-directed learners, and productive consumers. During the K-12 experience, students should encounter diverse and complex types of problems that arise from both the real-world and mathematical and scientific contexts. As students progress, their problem-solving skills should increase and their problem-solving strategies should become more sophisticated. These skills and strategies will help prepare students to meet the challenges of an ever-changing world.

The process of inquiry/problem solving is infused throughout the Nebraska Mathematics/Science Framework document and is exemplified in the instructional models. Students are given ample opportunities in the instructional models to ask questions and to design investigations to answer questions that are meaningful to them. Students are to use their current knowledge to explore and pursue answers to their questions. This involves observation, the collection and analysis of data, discussion, and presentation.

The process skills of learning used throughout the Nebraska Mathematics/Science Framework document have provided a means to connect mathematics and science. The identification of the process skills common to both mathematics and science helps teachers identify the skills that need to be experienced and practiced if students are to master inquiry/problem solving.

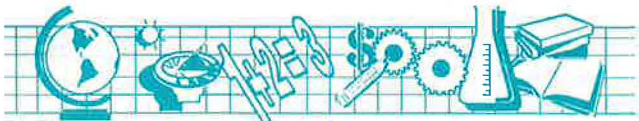
## *What is Inquiry/Problem Solving?*

According to the national standards documents, inquiry/problem solving involves making careful observations, posing questions, examining sources of information to see what is already known, planning investigations, developing sound and coherent predictions, making thoughtful analyses, proposing answers and explanations, and communicating results. A key component is the interactions among students, in particular the sharing of thoughts and problem-solving strategies. Learning often occurs when students explain their ideas in ways that their peers will understand and when students defend their viewpoints.

Inquiry involves students in the processes scientists and mathematicians use to obtain and evaluate data, and introduces them to the nature of scientific/mathematic investigations as a means to understand the natural world. Young people build critical-thinking skills when they are encouraged to become mathematicians and scientists - rather than simply studying about mathematics and science - by modeling the processes of inquiry/problem solving, and when the exploration focuses on the question, "How do we know?"

The purpose of problem solving/inquiry is to motivate students to learn and to provide real world context for examining issues. As students investigate their own interests and make connections between their experiences and those of the larger community, they realize that learning is an extremely valuable process.

Teachers need to provide opportunities for students to "do" science and mathematics — to design and conduct experiments, to identify and solve problems, to participate in hands-on activities, to ask questions, and to discuss and reflect on their findings. Instructional methods that support inquiry/problem solving include asking open-ended questions, sharing problem-solving strategies, and encouraging student interactions. Hands-on inquiry-based activities are included in the addendum.



# Multicultural Perspective

Multiculturalism is a positive facet of life in Nebraska. Many science and mathematic educators have different ideas about what multicultural education is and what it means to teach multiculturally. Educators need to expose students to a broad range of experiences, cultures, and perspectives. Knowledge of the culture, history, and the contributions of groups that make up the population of Nebraska and other parts of the country and world will foster respect for diversity and provide for improved interrelationships among individuals.

Multicultural education has many dimensions: community involvement, student performance, educator performance, learning environment, and policymakers. The diagram on page L – 13 illustrates these dimensions.

## *School is a Reflection of the Community*

The school is a reflection of the community including its ethnic, religious, and social values. Multicultural education emphasizes education that promotes the strengths and values of the community. Families and communities can help educators understand and appreciate the cultural richness of their population. Multicultural education presents a challenge and an opportunity for community members to work together with schools to educate students.

## *Student Performance*

Diversity has been a part of our country since its beginning. Multicultural education enables students to understand our country's racial, ethnic, and ancestral backgrounds. Infusing contributions and perspectives of many diverse groups into the curriculum helps prepare students to live, learn, and work in a pluralistic world.

Students need to develop a respect for different viewpoints, good listening and communication skills, and the ability to reason and share ideas with others. Students also need to apply their knowledge and skills to problems and investigations of local and global significance. They must understand that the world is very different from their own community.

## *Educator Performance*

Teachers need to know their students and respect their diversity. Successful educators are able to meaningfully interact with students whose cultures are different from their own. A variety of student-learning styles requires teachers to use diverse instructional strategies. Teachers need to have the capacity to instruct students from a variety of backgrounds; hold high expectations for all students; and be prepared to use appropriate instructional and assessment strategies and materials that will optimize learning for all students. Of paramount importance is the belief that all children are able to learn and do quality science and mathematics.

## Learning Environment: A Closer Look at a Multicultural Classroom

An observer in a multicultural classroom would see students grouped heterogeneously learning mathematics and science. In this setting, active students think and talk about mathematics and science with each other while respecting one another's viewpoint. Issue-oriented instruction would be used to promote authentic investigations and interactions among students. These students would be doing mathematics/science in the classroom, in the school yard, on nature trails, and at home as they puzzle over some of the wonders in their world.

Students would be connecting what is happening in the classroom to what is happening in their communities and the world. Teachers would be communicating with all their students and creating an environment in which all students feel comfortable interacting with the educator and other classmates. A variety of instructional strategies such as cooperative learning, the learning cycle, concept mapping, modeling, technology, role playing and simulations, storytelling, and use of investigations, community resources, and reflective thinking would be infused throughout the curriculum. The curriculum would reflect the experiences, cultures, and perspectives of a range of cultural, ethnic, and racial groups.

## Policymakers

In 1992, the Nebraska Legislature passed LB 922, a legislative bill that requires all public schools to infuse multicultural education into the K-12 curriculum. The law is intended to promote cultural appreciation, awareness, and sensitivity in students to better prepare them to function in the next century. It is the responsibility of local school districts to provide quality professional-development programs and resources to enhance education for all students.

Multicultural education is a strategy that promotes the strengths and values of diversity. We are challenged to consider how schools can incorporate students' cultural differences and values, while ensuring quality education for all. Nebraska's schools and communities need to play an active role in celebrating our nation's diversity.

# Dimensions of Multicultural Education

### *Community Involvement*

Strengthens community-home-school communication
Utilizes community resources which promote and model continued learning
Empowers students and family to become active participants in the processes of learning

### *Student Performance*

Develops personal communication skills
Recognizes and values cultural differences
Demonstrates respect for differing viewpoints

### *Learning Environment*

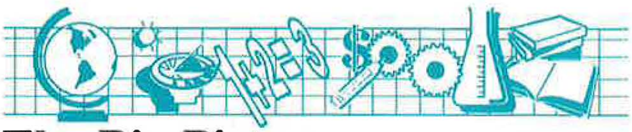
Promotes participation and high expectations of all students
Provides a safe place for exploration and interaction
Makes relevant resources available
Provides local and global perspectives
Promotes mutual respect

### *Educator Performance*

Develops personal communication with students and encourages student interactions
Uses a wide variety of instructional strategies to accommodate diverse student learning styles
Acquires knowledge and respect for diverse groups

### *Policy Makers*

Conducts staff development programs
Fosters respect for diversity
Provides pertinent resources



# The Big Picture

Mathematics and science education must be viewed within the context of a very complex system. The system includes the expectations and needs of students, parents, teachers, business and industry, and the professional mathematics and science communities; the school and university cultures; and the demands of traditional practices and the mathematics and science standards. Efforts to continually improve mathematics and science education are best accomplished through coordinated efforts at the federal, state, and local levels.

## *National Influence*

The development of voluntary national discipline-based standards is the foundation for improving education by providing a common vision of what students should know and be able to do. The development of national standards was launched by the National Council of Teachers of Mathematics (NCTM), who developed the national mathematics standards in 1989. The development of the national science standards has evolved through the efforts of several organizations and projects including Project 2061 and Scope, Sequence, & Coordination. The U.S. Department of Education, the National Science Teachers Association (NSTA), several scientific societies, and the National Education Goals Panel commissioned the National Research Council (NRC) to coordinate the development of a consensus document that establishes national standards for science education in grades kindergarten through twelve.

Federal support to encourage improvements in education and systemic reform is readily evident. There are numerous national programs available that are supportive of national mathematics/science standards and promote student-centered instruction. The graphic on page L – 17 reflects a small number of these programs. Goals 2000: Educate America Act is a national movement that provides federal funding to states to develop their own plan of action to help every child reach high standards. This federal support is augmented by national organizations of professional mathematics/science educators that provide products, services, and information that promote continual professional development.

## *Statewide Programs/Support*

Nebraska has nineteen intermediate educational service agencies known as Educational Service Units or ESUs. ESUs provide a multitude of services and professional development opportunities. These multi-county entities work closely with their local school districts and the State Department of Education to support and encourage school-level change.

Over the years Nebraska has secured a number of federally funded grants. These grants have allowed Nebraska educators to examine and modify innovative curriculum and instruction in mathematics and science to fit the needs and resources of Nebraska's classrooms.

The Nebraska Mathematics/Science Initiative (NMSI) is funded by the National Science Foundation and will continue at least through September, 1997. NMSI funding currently supports the development of distance-learning efforts including Math Vantage and Practical Pre-College Mathematics (PPCM). NMSI has helped create seven regional mathematics/science coalitions across the state to build community-based support for mathematics and science education. NMSI also coordinates a professional-development program through the PEERS Academy, a peer-taught two-week workshop that encourages teachers to collaborate with one another to enhance mathematics and science instruction.

State efforts to improve mathematics/science education is enhanced by state professional organizations. Nebraska Association of Teachers of Science and Nebraska Association of Teachers of Mathematics are state professional organizations that coordinate annual conferences and offer the opportunity for teachers to interact and collaborate with one another.

## *Role of Nebraska Department of Education*

The elected State Board of Education has the leadership responsibility to address the policy issues regarding quality education for all students in Nebraska, with the best-practice issues being the responsibility of the professional staff in the Nebraska Department of Education. On occasion, the legislature enacts into law statutes that address quality-education issues. The role of the Department of Education is to implement the intent of the law and/or promulgate rules and regulations which serve the interest of Nebraska students best.

Teacher certification and recertification are coordinated through the State Department of Education. Ad hoc committees are routinely formed to review existing teacher certification requirements in a five year cycle. The Mathematics Ad Hoc Committee has recently revised the requirements for a field endorsement in mathematics. The members of the committee and the revised requirements are found in the appendix. The Natural Sciences Ad Hoc Committee is in the process of revising requirements for teaching secondary science. Committee members involved in this process are listed in the appendix.

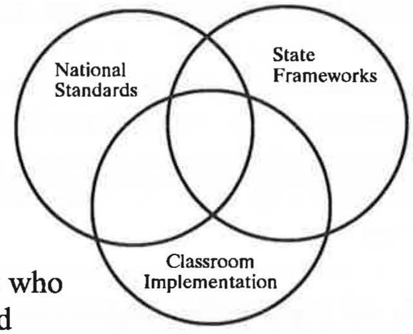
Professional-development activities and projects to enhance mathematics and science education are supported by Eisenhower funds, which are coordinated through the State Department of Education. The majority of the Eisenhower dollars are distributed to local school districts to support district curriculum plans/staff development.

One of the goals of the Nebraska Department of Education is to develop frameworks in each of the curriculum areas. State frameworks translate the national standards into classroom practice and provide models of best practices. The emphasis of the Nebraska Mathematics/Science Frameworks is on clear expectations of what all students should know and be able to do. The Mathematics/Science Framework Project is a major step toward beginning the process of consensus building to produce a common vision of mathematics/science education. The process to develop state frameworks promotes collaboration among students, parents, community, and educators in an effort to improve mathematics/science instruction and learning.

## *Summary*

The national standards have provided the foundation that has given direction to states as they have undergone the process of creating state frameworks. The state frameworks provide the needed guidance to transfer the national standards into actual classroom practice.

It is hoped that this will be an interactive process with practicing teachers influencing state frameworks and national standards and state frameworks impacting national standards and classroom practice.




The chart on page L – 17 shows some of the many components which interact to provide quality schools and education for all Nebraskans. The focal point is the student who is located in the classroom of the local school district. Good classroom teachers need to become proficient at using the national standards, national programs, state programs, and the Nebraska Department of Education to create the best learning environment for their students. National standards, national programs, and state programs influence each other, increase resources available, and provide ideas which enhance the educational environment students will experience.

The model activities which are included in this addendum are based on the national standards and state frameworks. These model activities were developed and piloted to aid in the process of implementing frameworks into classroom practice. Concept webbing was used to connect the mathematics/science-oriented activities to other subject areas and to the community. Community connections have been developed to create relevant learning situations for students. The resulting instructional models are student centered, interactive, participatory, and fun. Not only do they cross traditional disciplines, but they also include academic and cognitive challenges at many levels. These instructional models exemplify the type of learning that students in our state should experience.

The national standards movement presents teacher educators an opportunity and obligation to examine pre-service programs and implement changes needed to reflect the vision of the standards documents. This is an excellent opportunity for content departments and teacher education departments to collaborate and jointly design improved courses and programs. Nebraska postsecondary educators have met the challenge to examine, rethink, and offer suggestions for revising existing teacher preservice programs. The resulting document, *Guidelines for Teacher Preparation: Mathematics and Science*, is available by contacting Monty Fickel at Chadron State College or Carol Mitchell at University of Nebraska at Omaha. In order for the current reform effort to be successful, it must be a K-16 endeavor with all parties actively participating.

## *The Big Picture*

**National Initiatives**
- NCTM (National Council of Teachers of Mathematics)
  - Curriculum and Evaluation Standards
  - Professional Standards for Teaching Mathematics
  - Assessment Standards
- National Research Council
  - National Science Standards
- AAAS Project 2061 (American Association for the Advancement of Science)
- NSTA Scope Sequence and Coordination (National Science Teachers Association)
- Goals 2000: Educate America Act

**National Programs/Support**
- Family Math
- Family Science
- EQUALS
- Expanding Your Horizons in Math and Science
- GEMS (Greater Explorations in Math and Science)
- AIMS (Activities Integrating Math and Science)
- Project Wild & Project Aquatic
- National Diffusion Network (NDN)
- STS (Science, Technology and Society)
- NCTM (National Council of Teachers of Mathematics)
- NSTA (National Science Teachers Association)

# Nebraska Communities

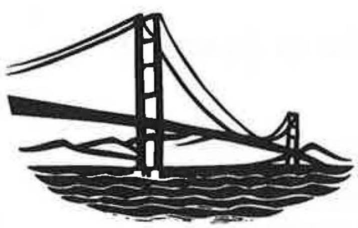
**Local School Districts**
**Classrooms**
**Educators & Students**

**Nebraska Department of Education**
- State Policies
  - Multicultural Education Rule 16
  - Writing Across the Curriculum Rule 10
  - Rule 10 Regulations and Procedures for the Accreditation of Schools
  - Teacher Certification/Recertification
- Eisenhower Professional Development Program
  - SMILES (Science, Mathematics, Integrated Experiences)
  - Nebraska Mathematics/Science Frameworks
  - Philosophy, Process Skills, and Content (1994)
  - Instructional Models and Assessment (1995)

**Statewide Programs/Support**
- ESU (Educational Service Units)
- NMSI (Nebraska Mathematics and Science Initiative)
  - Regional Coalitions
  - Math Vantage
  - PPCM (Practical Pre-College Mathematics)
  - PEERS Academies (Promoting Excellence in Education Regionally and Statewide)
- NATS (Nebraska Association of Teachers of Science)
- NATM (Nebraska Association of Teachers of Mathematics)

# *Bridging the Gap — Elementary Level #1*

**Materials/Supplies:**
Activity sheet/
purchase order
Clay
Straight pins or small nails
String
Tongue depressors
Straws
Thread
Masking tape
Toothpicks



**Topic Strands:**
Interdependence
Spatial Relationships/Geometric Topics
Data Analysis

**Conceptual Threads:**
Systems & Interactions
Problem Solving
Problem Solving

**Process Skills of Learning:**

| | | | |
|---|---|---|---|
| Communicating | Connecting | Measuring | Modeling |
| Problem Solving | Predicting | Questioning | Researching |
| Reasoning | | | |

**Why** (Purpose/Objective of the lesson):
To explore the use of appropriate tools and their practical application in building selected objects. By constructing a bridge model using geometric shapes, students are better able to develop and apply problem-solving strategies.

**How** (Procedure of the lesson):
1. Begin by telling the story of Emily Warren Roebling who faced the challenge of completing the construction of the Brooklyn Bridge after her engineer husband became ill. In those days, women were not welcome to enter scientific/mathematical careers. She overcame great odds to successfully complete the project and win the respect of fellow engineers.
2. Present challenge to design a bridge. Sketch proposed bridge and estimate its costs using the following specifications:
   a. Students work in bridge-building companies (small groups) of three to five students, with every company having an equal number of members if possible.
   b. The bridge must span the distance between two desks that are placed so a gap is created between them. (With fifth graders, this gap normally measures 30 centimeters).
   c. Only the supply materials listed on the purchase order may be used to construct the bridge. Students are given a list of these materials prior to sketching their bridge design.
   d. Students are allowed to measure the cement prior to determining the amount they want to purchase.
   e. Students are allowed to test the strength of different geometric shapes and supplies prior to sketching their bridge design.
   f. Bridge constructions are evaluated on their capacity to hold weight. Design/size of bridge platform may need to provide for applying weights depending on the format chosen to test this capacity. Students need to know (how their bridge will be assessed) prior to designing and building their bridges.

# *Bridging the Gap — Elementary Level #1*

   g. Using the purchase order sheet, the group will determine needed materials and calculate the cost of constructing their bridge.
3. Construct bridges.
   a. Share and evaluate bridge building problem-solving strategies/designs.
4. Estimate, then test strength of bridges.
5. Collect data on bridge strength. Present in graph form.
6. Students develop and test new construction plan based on what they have learned.
7. Debrief activity.
   a. Which materials created the strongest bridges?
   b. What construction ideas were used by the groups?
   c. What surprised the students most?
   d. List 3 things that could be done to improve each bridge.
   e. Describe geometric shapes used and compare their strength.

**For Your Information** (Background information for the lesson):
1. Suggested unit prices for bridge samples:
   a.

| Supply | Supply Substitute | Cost/Amount |
|---|---|---|
| Cement | Clay | $50,000/100 grams |
| Rivets | Straight Pins | $1,000/each |
| Cable | String | $10,000/decimeter |
| Steel Beam | Tongue Depressors | $20,000/each |
| Guide Wire | Thread | $1,000/decimeter |
| Steel Girder | Straws | $10,000/each |
| Struts | Toothpicks | $5,000/each |
| Trussing | Masking Tape | $10,000/meter |

2. Additional resources:
   a. *Tar Beach* by Faith Ringold. Also available on video.
   b. National Parks film on the St. Louis Arch.

**Suggested Instructional Strategies:**
Bridges are built in groups of 4-6 to allow for maximum idea generation and interaction.

# *Bridging the Gap — Elementary Level #1*

**Additional Activities** (Extensions):

1. Invite engineer or construction worker to review student bridges and discuss bid and actual bridge costs.
2. Students can make the connection between the structure of a bridge and the structure of the skeletal system. The cylindrical shape of straws is similar to cylindrical shape of leg bones which allows for optimum weight-bearing capacity.
3. Read and discuss "Emily's Triumph" (Silver-Burdett, Dream Chasers, Grade 5), which gives the complete story of Emily Warren Roebling.
4. Research the history/functions of local bridges as well as bridges throughout the world.

**Possible Assessment Ideas:**

**Outcome:** Through problem solving and group cooperation, students connect their understanding of the strength of geometric shapes and apply it to bridge construction.

**Task:** Design and build a bridge to meet specifications of span strength and effectiveness.

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Problem Solving | All specifications met completely; as obstacles arise, group develops alternate plans that improve the bridge. | Met most but not all specifications; as obstacles arise, group develops alternate plans without improving the bridge. | Met few, if any, of the specifications; as obstacles arise, the group ignores or minimumly addresses the problem. |
| Utilization of purchase order | Accurately predicts amount of needed supplies; uses materials in most functional ways; accurately completes computation tasks on purchase. | Plan does not reflect actual purchasing; materials used in functional ways; computation has little or no errors on purchase order. | Predicts materials in unreasonable quantities; uses materials ineffectively; inaccurate/incomplete computation tasks on purchase order. |
| Bridge Strength | Strength of bridge exceeds weight requirement. | Strength of bridge meets weight requirement. | Strength of bridge does not meet weight requirement. |
| Cooperation within a group | Consistently and actively shares tasks/roles; consistently encourages others; acceptance and discussion of other's ideas; project completed. | Inconsistent sharing of tasks/roles (though observable most of the time); some encouragement of others; sporadic sharing and discussing of ideas; completes the project. | Monopolizes or uninvolved; consistent put-downs and no productive arguments; little or no encouragement; project not completed. |

# *Sky High — Elementary Level #2*

**Materials/Supplies:**
Activity sheet
Science resource books (dealing with solar system)
Calculators
World map
Yarn

**Topic Strands:**
Universe
Measurement

**Conceptual Threads:**
Scale and Structure
Estimation

**Process Skills of Learning:**
Communicating
Interpreting Data
Problem Solving
Researching

**Why** (Purpose/Objective of the lesson):
To investigate relationships of distances in space and verify reasonableness of information.

**How** (Procedure of the lesson):
1. Prepare classroom with student chairs arranged like the seats in an airplane. (Ideas: Row and seat numbers on chairs; hand out seat assignments and boarding passes as students enter; play tape recording of pilot welcoming them—leave destination open ended).
2. Students pick a global destination and find the cost of a round trip at a rate of one cent per thousand miles.
3. Record students' global destination choices along with their reasons for selecting their destination. What would the students expect to see, hear, smell, touch, and taste once they arrive?
4. Have students map out their global destinations on a wall map by using a specific color of yarn for each continent. How many meters of yarn would we need if 1 cm = 1,000 miles?
5. Figure the distance of a light year.
6. Calculate the total cost of flying to all listed locations within our solar system.
7. Small groups of students then calculate the cost of flying to locations outside our solar system.
8. Students explain the strategy they used to find the cost of their trip.
9. Present Sky High activity sheet to students. Facilitate their investigation of the activity.
   a. Do students agree with information?
   b. Are the figures reasonable?
10. Share thinking/problem-solving strategies.
11. Facilitate students' work on additional activities.

**For Your Information** (Background information for the lesson):
1. Children's understanding of the size of the Earth and the universe gradually increases through their experiences with the sun, moon, and stars. These vast distances in space are made more meaningful to students through their own investigations.

# *Sky High — Elementary Level #2*

2. If the distance was 25 trillion miles (25,000,000,000,000) at a rate of 1¢ per 1000 miles, it would cost 25,000,000,000¢ or $250,000,000. To change pennies to dollars, divide by 100 by moving the decimal two places to the left or multiply by .01.
3. **Distances in Space** — A light year is approximately 5.878 trillion miles. Light travels at 186,282 miles/second. Distances are the average of perihelion (closest) and aphelion (farthest). It is recommended that students research these distances.

| Object In Space | Closest approach to Earth | Mean Distance from Sun |
|---|---|---|
| Moon | 238,857 miles | — |
| Sun | 93,000,000 miles | — |
| Mercury | 57,000,000 miles | 35,800,000 miles |
| Venus | 25,700,000 miles | 67,200,000 miles |
| Mars | 48,700,000 miles | 141,600,000 miles |
| Jupiter | 390,700,000 miles | 483,600,000 miles |
| Saturn | 762,700,000 miles | 886,700,000 miles |
| Uranus | 1,700,000,000 miles | 1,783,200,000 miles |
| Neptune | — | 2,794,200,000 miles |
| Pluto | — | 5,900,000,000 miles |
| Chiron (Asteroid orbiting between Saturn and Uranus) | — | 1,273,500,000 miles |
| Haley's Comet | 1,652,300,000 miles | — |

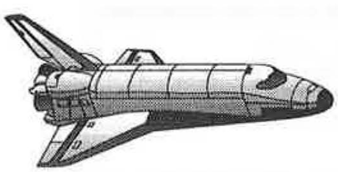
| Object in Space | Closest approach to Earth |
|---|---|
| Alpha Centauri - nearest 3rd brightest star | 4.3 light years or 25 trillion miles |
| Sirius - brightest star | 8.8 light years or 50 trillion miles |
| Canopus - 2nd brightest star | 100+ light years |
| Arcturus - 4th brightest star | 36 light years |
| Vega - 5th brightest star | 26 light years |
| Ring Nebula (in Lyra) | 15,000 billion miles |
| Small and Large Magellanic Clouds | 200,000 light years |
| Andromeda Galaxy - twin galaxy | 2.2 million light years or 13 million, million, million miles |
| Quasars (at the limit of the known Universe) | 7 billion to 13 billion light years |

# *Sky High — Elementary Level #2*

4. NASA regional resource center in Lincoln has additional information and videotapes available. Phone: (402) 472-6302. See page J–2 of the original document for address.

**Suggested Instructional Strategies:**
The classroom is organized like the cabin of an airplane. Students work in small cooperative groups. Team teaching with Reading and/or Language Arts teacher is helpful.

**Additional Activities** (Extensions):
1. Investigate cost of one cent per 1,000 miles compared to available airline rates (e.g., airline newspaper ads, travel agent).
2. Explore and compare travel costs using various forms of transportation.
3. Examine undersea travel and compare to space travel: types of vehicles used, equipment needed, time involved, cost efficiency, and research purposes.
4. Have students work in groups to research a planet and create critters that could survive on their planet. Explain adaptations to class.
5. Multicultural Connection: encourage students to research scientists contributing to the space program (e.g., Maria Mitchell, Neil Armstrong, Hantaro Nagaoka, Benjamin Banneker, Valentina Tereshkova, Subrahmanyan Chandrasekhar, Nicolaus Copernicus, Galileo Galilei, Robert Goddard, Sir William Herschel, Johannes Kepler, Sir Isaac Newton, Sally Ride, or Carl Sagan).
6. Teacher reads *A Day of the Earthlings* by Eve Bunting.
    a. Stop and have the students predict what will happen next. Record predictions in student journals.
    b. Create a video tape of a commercial advertising a selected destination.
    c. Additional literature connections:
        "Close Up Look at Mars" from *Dreamchasers*, Silver Burdett-Ginn; and *The Magic School Bus, Lost in Space* by M. Cole.



7. Take a field trip to a planetarium, airport, travel agency or have a pilot, travel agent, and/or astronomer visit the classroom.
8. Create a travel poster and/or brochure.
9. Make a paper mache model of planets.

**Possible Assessment Ideas:**
1. Students' performance in additional activities section can be evaluated.
2. Reasonableness of findings. Is the cost calculated accurately? Can students clearly explain how they arrived at the cost?

# *Sky High — Elementary Level #2*

**Possible Activity Sheet:**
"If it cost one cent to ride 1,000 miles, a trip around the world would cost 25 cents. A trip to the moon would cost $240, and a trip to the sun, $930. But a trip to Alpha Centauri, the nearest star system, would cost $260 million." — Reader's Digest, October 1993

Do students agree with these figures?

Are the figures reasonable?

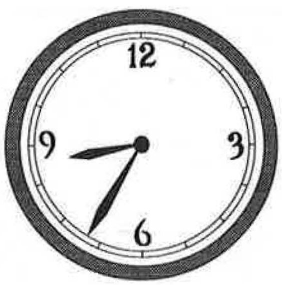
Students share their thinking/problem solving.

Students may extend this problem as they choose.

# *Tinkering With Time — Elementary Level #3*

**Materials/Supplies:**
Various kinds of clocks
screwdrivers (phillips & regular)

Various books such as: *The Grouchy Ladybug* by Eric Carle, *Clocks & More Clocks* by Pat Hutchins, and *Time to...* by Bruce McMillan




**Topic Strands:**
Force and Motion
Measurement
Measurement

**Conceptual Threads:**
Scale and Structure
Problem Solving
Technology

**Process Skills of Learning:**
Classifying
Measuring
Observing
Problem Solving
Predicting

**Why** (Purpose/Objective of the lesson):
To observe what makes a clock work. Explore and classify clock parts according to purpose and geometric shape.

**How** (Procedure of the lesson):
1. Read *The Grouchy Ladybug* by Eric Carle.
2. Discuss time and its role in students' lives.
3. Examine various clocks, such as digital, electric, and battery.
4. Classify clocks as a large group.
5. Draw a picture as a prediction of the inside of a clock.
6. Explore parts of clock. Rules: can't break clock, can't cut wire (teacher will cut). Look for geometric shapes and angles in the parts of the clock.
7. Draw picture of inner workings of the clock.
8. Compare and classify the parts of the clock.
9. Use the clock parts as non-standard tools to measure items in the classroom.
10. Measure clock parts with standards units of measure.

**For Your Information** (Background information for the lesson):
By taking the covers off and looking inside, you can see the way a machine works. Mechanical machines have working parts. Parts may be springs, cranks, gears, levers, wheels, etc.

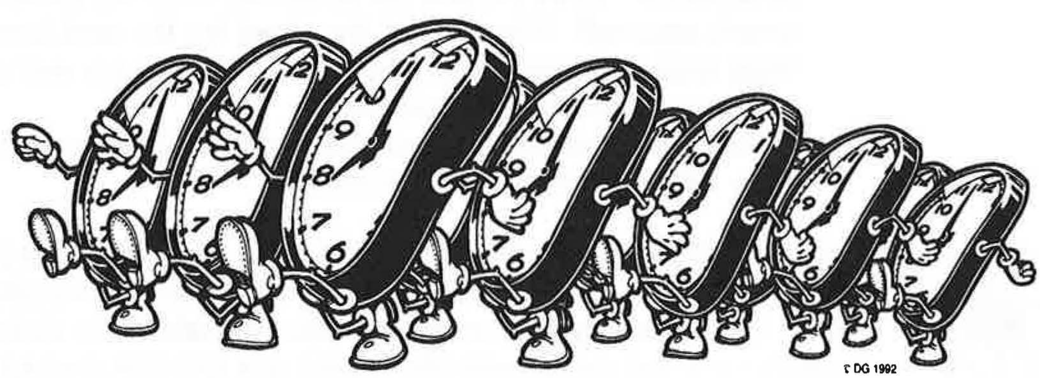
**Suggested Instructional Strategies:**
The students will work in small cooperative groups. All students will be involved in exploration and group discussion. Multigrade groups may be helpful in taking the clocks apart. Group discussion.

**Additional Activities** (Extensions):
1. Order the parts by size.
2. Which clock had more parts?
3. What made the sound in the machine?
4. Students bring other machines to take apart.
5. Weigh like parts on balance scale.

# *Tinkering With Time — Elementary Level #3*

6. Tie into shadows, telling time, sundials, hourglass, egg timer, new moons, and various kinds of clocks as ways to tell time.
7. Read either or both of the following books to the students: *Clocks and More Clocks* by Pat Hutchins or *Time to...* by Bruce McMillan. Create a "Telling Time" book showing what students are doing at various times of the day.
8. Invite a repairperson to discuss clocks and other small machines.
9. Students can write word problems dealing with time.
10. Visit a jeweler or clock shop.
11. Research history of time and time in other cultures.
12. Put clocks back together.
13. Create a time-telling device.

**Possible Assessment Ideas:**
Students will develop a classification system (i.e., chart, table, Venn diagram, dichotomous key) that will explain their groupings of clock parts. Teacher observes student interactions and watches for the following skills: variety of attributes used in classification, working cooperatively, communicates reasonableness of classification, identifies clock parts, and refers to parts using geometric terms.



# *Bugs On a Stick — Elementary Level #4*

**Materials/Supplies:**
Colored/opaque plastic cups
Sticky substances (jelly, honey, Vaseline, peanut butter, white Karo syrup, molasses, etc.)
Electric fence posts or dowels

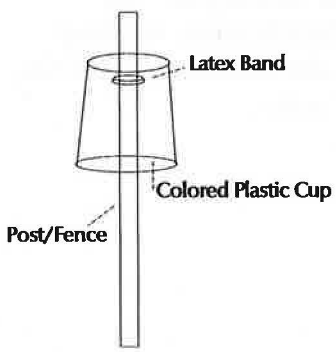
**Topic Strands:**
Diversity
Data Analysis

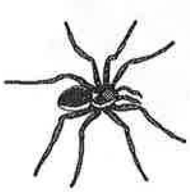
**Conceptual Threads:**
Scale and Structure
Problem Solving

**Process Skills of Learning:**
Hypothesizing
Problem Solving
Interpreting Data
Observing
Predicting
Classifying

**Why** (Purpose/Objective of the lesson):
To classify and study insects. This lab also is designed to formulate and test a hypothesis.

**How** (Procedure of the lesson):
1. Discuss factors which may attract insects.
2. Have students work in small groups to make the insect-collecting device at the left. The class decides a variable to investigate. Possible variables to investigate include: color of container, type of container, type of substance (sticky or otherwise), location of container.
3. Share the assessment rubric with students. Use to the degree applicable for your grade level.
4. One attribute is chosen by students to classify insects. Possible attributes are size, color, or body parts.
5. Discuss appropriate question(s). Which color of cup attracts the most insects? Does the position of the cup affect the number of insects captured? What area of the school has the most insects? What sticky substances work the best? What changes would students make in their experiment?
6. Students graph number of bugs collected by selected variables. Class data is averaged when possible.

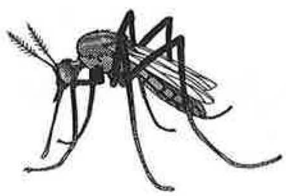


**For Your Information** (Background information for the lesson):
"Bugs on a Stick" is a lab designed to allow students to formulate and test a hypothesis they have proposed. This lab makes a nice closing activity for a unit on the scientific inquiry or a nice introductory lab for a unit on insects.

The objective of the lab is to find a method that will capture insects, Working within their lab groups, students first formulate a hypothesis to test. Raw data are analyzed by graphing and students discuss whether or not their hypotheses are supported, any changes they would make in their experiments, and any sources of error.

# *Bugs On a Stick — Elementary Level #4*



One way to catch insects is to coat a plastic cup with Vaseline. The best time to do this activity is in early fall.

**Suggested Instructional Strategies:**
Students will work in small cooperative groups. The teacher acts as facilitator and discussion leader in developing the insect unit.

**Additional Activities** (Extensions):
1. Use microscope slides with Vaseline on them. Then look at the captured insects under the microscope or with a hand-held magnifier.
2. Illustrate insects as viewed under the microscope.
3. Plot migration paths of selected insects (i.e., killer bees, or monarch butterflies).
4. Investigate uses of insects by cultures throughout the world (i.e., food source, religious rites, or medicine).
5. After catching their "bugs," students could write a poem about a bug they caught.
6. Use dirt cups as an anticipatory set or culminating activity.

DIRT CUPS

1 pkg. 16 oz. chocolate sandwich cookies
2 cups cold milk
1 pkg., 4 serving size, chocolate instant pudding
1 tub, 8 oz., whipped topping
10 clear plastic 7 oz. cups
gummy worms or frogs

1. Crush cookies in a plastic bag with a rolling pin.
2. Pour milk in a bowl and add pudding. Mix 1-2 minutes and let stand for five minutes.
3. Stir whipped topping into pudding mixture. Also stir in 1/2 crushed cookies.
4. Put 1 TB. crushed cookies in bottom of 7 oz. cups. Fill cups 3/4 full with pudding mixture. Top the cups with remaining crushed cookies.
5. Refrigerate 1 hour. Decorate with gummy worms or frogs.

**Another Approach:**
A variety of instructional strategies should be used to accommodate multiple learning styles. Structured activities are important to the development of inquiry and problem-solving skills. As the school year progresses, a natural evolution is to incorporate student-centered activities where the students are actively involved and responsible for their own learning. A student-centered approach to "Bugs On a Stick" follows."

# *Bugs On a Stick — Elementary Level #4*

## A Student-Centered Approach

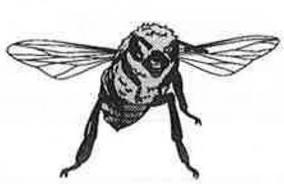
**Topic Strands:**
Diversity
Data Analysis

**Conceptual Threads:**
Scale and Structure
Connections, Communications

**Why** (Purpose/Objective of the lesson):
This open-ended lab is designed to allow students to formulate and test a hypothesis they have proposed.

**How** (Procedure of the lesson):
1. Brainstorm what they know about insects including how to collect them.
2. Share the assessment rubric with students prior to the activity. Use to the degree applicable for your students.
3. Students design a system that can be used to collect a variety of insects for scientific study.
4. Estimate, count, classify, and graph the number of insects collected. Calculate ratio and percentage of one type of insect to the total population caught. Write math story problems to go with this activity. Examples are located in "For Your Information."
5. Students will complete a written lab which shows evidence of their use of the scientific inquiry and includes the question, hypothesis, materials, procedure, data, results (graphs), and conclusion.
6. Share strategies for collecting insects and what they have learned. How does color, location, or other variables affect insect collection?
7. Students will communicate what has been learned.

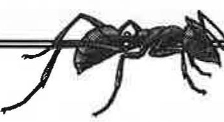
**Additional Activities** (Extensions):
1. Design an insect to flourish in a specific environment of the student's choice. Explain/demonstrate adaptations to the class.
2. These literature selections can be used during and/or following the lesson. Use drama, puppets, student-made books, art activities, or role playing to enhance the literature selections (*The Grouchy Ladybug* by Eric Carle; "The Ant and the Grasshopper," folktale; *The Ladybug and Other Insects Book*, First Discovery Book; *Old Black Fly* by Jim Aylesworth; *How Many Bugs in a Box* by David Carter; or *The Very Quiet Cricket* by Eric Carle).
3. Invite a beekeeper and/or pest control worker to speak to the class.



# *Bugs On a Stick — Elementary Level #4*

**Possible Assessment Ideas:**
This is an open-ended activity which could be used as an assessment activity for the scientific method.

Assessment Checklist



| Demonstrates | Does Not Demonstrate | Behavior |
|---|---|---|
| | | 1. Exhibits evidence of using the five senses for observation purposes. |
| | | 2. Records observations in a systematic manner. |
| | | 3. Hypothesis is stated clearly and concisely. |
| | | 4. List of materials is complete. |
| | | 5. Procedure is written clearly so that it can be easily understood and followed. |
| | | 6. Data is complete and organized. |
| | | 7. Only one variable was manipulated. |
| | | 8. Created a graph which clearly represents data collected. |

# *Bugs On a Stick — Elementary Level #4*

**Outcome:** Design and conduct an experiment involving a living organism.

**Task:** "Bugs On a Stick" — design an experiment to collect the most bugs.

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Hypothesizing | Clear, concise statement of the problem. | Problem is stated but needs help with clarity. | Needs a lot of help in writing the problem. |
| Communicating | Complete list of needed materials. Procedure is written so anyone could duplicate the experiment. | Incomplete list of needed materials. Procedure is written, but one or two steps are left out. | Little or no materials listed. Many steps in the procedure are left out. Experiment could not be duplicated. |
| Understanding Variables | Only one variable is changed. | More than one variable is changed. | Did not attempt to control any variable. |
| Measuring (Graphing) | Bar graph with a title and both axes are correctly labeled. | Bar graph is not labeled correctly. | Incomplete bar graph. |
| Observing | Detailed map of area. Data complete and organized. | Map has details omitted. Data complete but not organized. | No map. Data incomplete and without organization. |
| Reasoning | Written conclusion is supported by data collected. | Written conclusion is not supported by data collected. | No conclusion. |

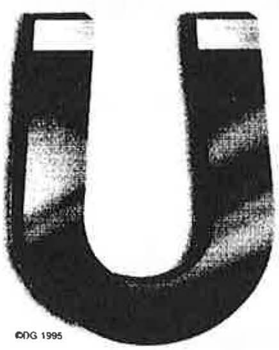
# *Magnificent Magnets — Elementary #5*

**Materials/Supplies:**
Various shapes and sizes of magnets, cow magnets
Paperclips
Cardboard
Markers

**Topic Strands:**
Force and Motion
Force and Motion
Data Analysis

**Conceptual Threads:**
Patterns of change
Energy
Problem Solving

**Process Skills of Learning:**
Communicating
Interpreting Data
Observing
Problem Solving




**Why** (Purpose/Objective of the lesson):
To demonstrate how forces can be used to make objects interact, move, stop, or change directions.

**How** (Procedure of the lesson):
1. Teacher shares and discusses a refrigerator magnet with the class.
2. Select six items in the room that are believed to be magnetic.
3. Students test their predictions.
4. Explore what magnets can do.
5. Determine the strengths of the magnets from the strongest to the weakest.
6. Estimate the number of paperclips various magnets will pick up.
7. Construct a class graph and analyze the results.
8. Students will work in small groups to create a magnet game and share their game with others (maze, street scene, racetrack)
9. Estimate, then time the movement through the maze.
10. Discuss how magnets are used in our daily lives.
11. Culminating activity: read *Mickey's Magnet* by Franklyn M. Branley and Eleanor K. Vaughan.

**For Your Information** (Background information for the lesson):
1. The strength of the magnetic force is dependent upon the materials composing the items being tested.
2. Cow magnets are inserted into cows to prevent barbed wire from damaging their stomachs.
3. Related resources: AIMS - Mostly Magnets, Mudpies to Magnets.

**Additional Activities** (Extensions):
1. Experiment with iron filings to make patterns. Illustrate, design, and write a statement about why the filings reacted the way they did.
2. Paint a picture using a magnet and paper clip. Place several drops of paint on a piece of paper in a shoebox lid. Place the paper clip in the paint. Create a picture by moving the magnet under the lid.

# *Magnificent Magnets — Elementary #5*

3. Use a magnet to find objects in a treasure chest (shoe box filled with rice).
4. Write directions and share games with another classroom or grade level.
5. Create a 3-D magnet using a plastic pop bottle of baby oil and iron filings. Fasten a test tube down into the bottle and place a cow magnet in the test tube. Cushion the test tube with a cotton ball. When the cow magnet attracts the filings it will be a 3-D effect.
6. Have students compile a list of items in their home that utilize magnets.
7. Research the history of magnets and find out how they are used in various fields — technology, medicine, and industry — around the world.

**Suggested Instructional Strategies:**
Students will work cooperatively in small groups.

**Possible Assessment Ideas:**
Use rubric to assess the creation and completion of magnet game.

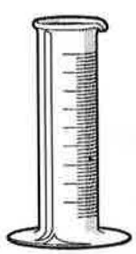
**Purpose:** Students will demonstrate how force can be used to make objects interact.

**Task:** Mattel is looking for new games for their Christmas line. Each student is part of a team that is creating a new game using magnets. First, think of ways that magnets can be used. Second, plan a game in which magnets can be used. Third, build the game and plan ways to make it attractive. Each team then tells the class how to play the game.

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Communication | Gives most of the rules of the game. | Gives some of the rules of the game. | Gives no rules for the game. |
| Cooperative Learning | Listens to others. Takes turns. Encourages others. | Listens occasionally; occasionally takes turns; encourages and puts down the group. | Does not listen to others; does not take turns; puts down others. |
| Problem Solving | Understands directions; gathers ideas with group; makes a plan for a game. | Directions are not clear; some difficulty gathering ideas; makes a plan with teacher/peer assistance. | Does not understand directions; group has few ideas; no plan for a game. |
| Product | Demonstrates a clear understanding of magnetic strength and magnetic poles. | Makes some attempt at demonstrating magnetic strength; some understanding of the magnetic poles. | Demonstrates no progress in the understanding of magnetic force in their game. |

# *Rising to the Top — Elementary #6*

**Materials/Supplies:**
Graduated cylinders
Various objects that will sink or float
Book: *Mr. Archimedes Bath*
Clay
Balance scales
Weights



**Topic Strands:**
Number Sense
Data Analysis
Matter

**Conceptual Threads:**
Connections
Problem Solving
Systems and Interactions

**Process Skills of Learning:**

| | | |
|---|---|---|
| Observing | Problem Solving | Predicting |
| Communicating | Interpreting Data | Measuring |

**Why** (Purpose/Objective of the lesson):
To demonstrate, observe, collect data, predict, and communicate that matter occupies space and has weight.

**How** (Procedure of the lesson):
1. Read *Mr. Archimedes' Bath* by Pamela Allen.
2. Students work in small groups to predict and explore the rising of water using a variety of objects.
3. Experiment by placing various objects into a graduated cylinder or beaker filled with water.
4. Collect data during exploration. Record data.
5. Predict the object's mass.
6. Use a balance scale and weights to explore and compare weight, volume, and size of the objects.
7. Collect and record data.
8. Graph results with mass on vertical axis and volume on horizontal axis.

**For Your Information** (Background information for the lesson):
1. Flexible plastic cylinders are better than glass or hard plastic because they are less likely to crack or break.
2. If graduated cylinders are not available, use a clear plastic cup and establish marks using a non-standard "unit." Objects should be large enough to raise water at least 1 unit.
3. The amount of water displaced will be the volume of the object. The difference between the weight of the object in the air and the weight in the water will be close to the volume of the object.
4. Younger students may be more successful if beakers are used instead of graduated cylinders.
5. Clay is essential to have available as one of the various objects for the comparison of size and mass. Use clay to create similar-shaped objects with different masses or similar-massed objects with different shapes to lead students to discover that it is not mass that displaces water but the volume of the objects.
6. A reference book is AIMS *Floaters and Sinkers.*

# *Rising to the Top — Elementary #6*

**Additional Activities** (Extensions):

1. Use various-sized, marshmallow-filled containers to experiment with volume.
2. Substitute various liquids such as oil, soap, or salt water for the water.
3. Experiment with larger objects such as fruits and vegetables, regular soda and diet soda to see what will sink and float.
4. Use three film canisters containing 14, 7, and 0 pennies, respectively. Predict whether they will sink or float. Experiment and record observations. Explain results. (*Super Science Blue*; April, 1995; Scholastic Magazine).
5. Make a clay boat. Estimate the number of paper clips the boat will carry before sinking. Test prediction.
6. Research history of water transportation and how it is used in other cultures.

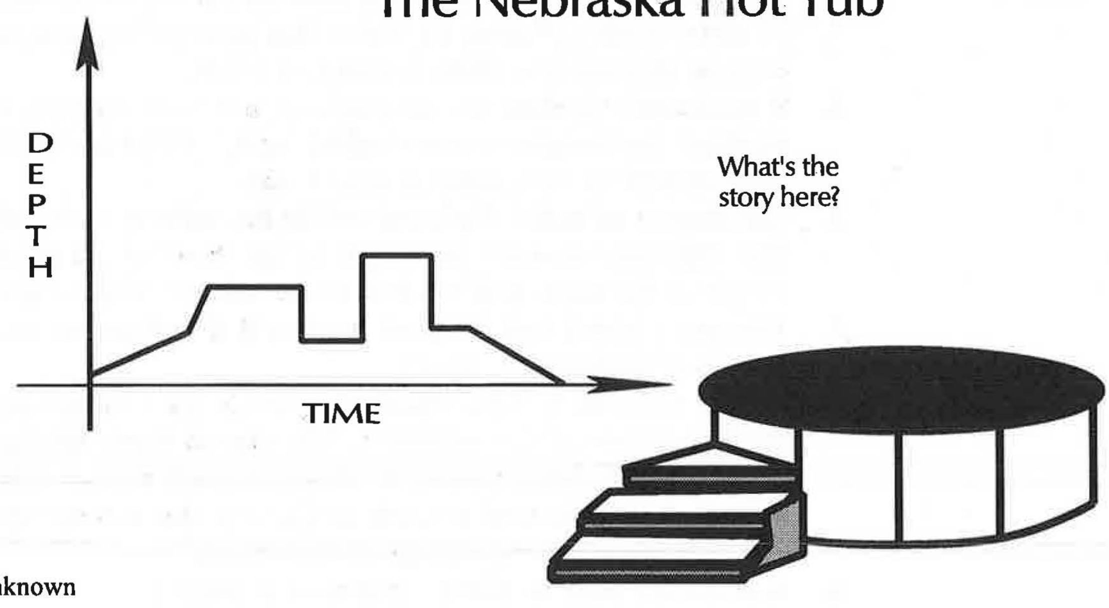
**Suggested Instructional Strategies:**

1. Students work cooperatively in small groups of 3-4.
2. All students will be involved in exploration.
3. Teacher acts as a facilitator using questioning strategies to enhance inquiry.

**Possible Assessment Ideas:**

1. Graph findings.
2. Write a story to explain the Nebraska Hot Tub graph.

## The Nebraska Hot Tub

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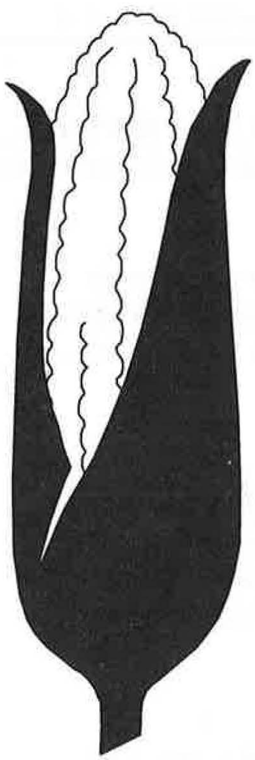
# *We Challenge Orville — Middle Level #1*

**Materials\Supplies:**
Several brands of popcorn, such as maize, field corn, commercial products
Popcorn poppers
Graphing calculators
Measuring cups
Bowls (clear and large to measure volume)
Paper bags
Coffee filters



**Topic Strands:**
Matter
Number Sense
Data Analysis

**Conceptual Threads:**
Patterns of Change
Communications
Problem Solving

**Process Skills of Learning:**
Communicating
Measuring
Connecting
Observing
Interpreting Data
Predicting

**Why** (Purpose/Objective of the lesson):
To illustrate, by using popcorn, how numerical representations relate to quality control, the density of the kernels, and to moisture content.

**How** (Procedure of the lesson):
1. Display different types of corn at the front of the room.
2. Discuss by comparing and contrasting different types of corn.
3. Assign groups to pop one of the different types of corn.
4. Refer to student guide for procedure.
5. Use graph paper to make coordinate axes. Construct comparable graphs by graphing total number of kernels on the horizontal (*independent* or *manipulative* variable) and popped kernels vertically (*dependent* or *responding* variable).
6. Line of best fit. Lay ruler on its edge. Begin by placing left end of ruler at the ordered pair (0,0). Not all best fit lines will go through the point (0,0). Move ruler so that half of the points are above and half below the line. Lay the ruler down and draw the line of best fit.
7. Percentages-fractions-decimals — write popcorn popped as a percentage, fraction, or ratio.
8. Graphing calculators — have an upper-level algebra class demonstrate the use of a graphing calculator.
9. To explore Native American myths have students write their own legend of why popcorn pops. Begin by reading the story *"The Coming of Corn"* found in the book *Keepers of the Earth* by Michael J. Caduto and by Joseph Bruchac.
10. Have students explain in story form why they think popcorn pops.
11. Determine the density of popped and unpopped kernels. Graph the mass and volume.
12. Test the moisture content by weighing, drying, and weighing again; and compare to probability, as well as why the popcorn does pop.
13. If possible, have moisture content verified by county agent or representative of Farmers' Coop. Truth in advertising could be investigated.

# *We Challenge Orville — Middle Level #1*

14. Rate the brands of popcorn using graph results. Have students determine cost per ounce of each brand. Does this change the students' opinions of which brand is best? Explain.
15. Write advertisements to "sell" each group's popcorn brand.

**Another Approach:**
Students completing the structured activities described in #1–15 will limit their explorations to the questions asked by the teacher. They will probably not generate their own questions and class members will produce similar results. The students will focus on completing the activity. To reduce these limitations and allow students to explore, discover, and develop their own method to solve a problem, a more open-ended approach may be used. Using an inquiry/problem-solving strategy will produce a wide range of products as students define their problems differently and use different strategies to reach their conclusions. This method challenges the students to reach their potential using skills which have been developed in other activities.

***A Student-Centered Approach:***
Design an experiment to determine which popcorn is best. Students should experiment, collect and analyze data, and present their results to the class.

**For Your Information** (Background information for the lesson):
Students need to have access to the same kind of popcorn popper to make circumstances equal. Graphing calculators can be used to graph results.

**Suggested Instructional Strategies:**
Use group discussions and cooperative groups to problem solve and investigate. Teacher acts as facilitator and discussion leader. Use community resources such as extension agents, elevator operators, and farmers. Use graphing calculators or computer graphing programs.

**Additional Activities** (Extensions):
1. Use kernels to exhibit exponential estimation.
2. Make popcorn balls with mixing colors. Do cost analysis of making and selling popcorn/popcorn balls. Create commercials and record on video tape.
3. Investigate other properties of corn-weight changes, color, density, etc.
4. Compare commercial brands of popcorn and homegrown popcorn.

# *We Challenge Orville — Middle Level #1*

5. Instead of counting kernels, measure a quantity (⅓ cup), count the kernels in the sample and compare volumes of popped popcorn as well as the number of unpopped popcorn.
6. Explore the temperature a kernel of popcorn will pop at or the effect of the type of popcorn popper (hot air, grease, etc.) used.
7. To compare quality and quantity, use 200 kernels of each brand. Repeat each trial to increase validity.
8. Rank the popcorn by taste.
9. Take the top off an air-popper and predict where and how far the popcorn will land.
10. Wrap tin foil tightly around an ear of popcorn with the small end down. Carefully slip the ear of popcorn out of the foil leaving the mold. Estimate how much of the mold will be filled when the popcorn is shelled. Shell the popcorn from the ear and return the kernels to the tinfoil cast. The kernels will fill the foil completely. The cob will be left over. It looks like matter was created. Why?
11. Investigate the effects of refrigeration or age on popcorn kernels.
12. The slope of the graphs can be used to show several scientific principles; e.g., velocity, acceleration.
13. Graph mass and volume. Use internet to compare results with a group that lives at a much different altitude.

**Possible Assessment Ideas:**

1. Student performance. Criteria is specified in sample rubric.
2. Student involvement in group sharing of ideas.
3. Authentic task quiz on fast foods to assess each student's ability to graph a best fit line is found on page L – 40.

# *We Challenge Orville — Middle Level #1*

**Sample Rubric:**

| Criteria | Proficient | Promising | Basic | In Progress |
|---|---|---|---|---|
| Collection and Representation of Data | Data collected accurately, well-organized (table form and in order), all data complete and identified. | Data collected accurately, organized in table form, and identified. | Data collected accurately in table form. | Data collected with some inaccuracy or omissions, may or may not be in table form or identified. |
| Graph of Data | Graph is neat and organized, has all labels, scale is appropriate. | All points are plotted, axes are labeled, scale is appropriate. | All points are plotted, scale is appropriate. | Scale is not appropriate, not labeled, points plotted incorrectly or omitted. |
| Graph Line of Best Fit | Median points are graphed and identified. Line is in the correct position and appears to "fit the data." | Median points are graphed. Line is in the correct position. | Median points are graphed. Line is between the median points but located incorrectly. | Median points are graphed but may be incorrect. Line appears to not "fit" the data. |
| Equation of the Line of Best Fit | Equation is correct. The method is correct, which can be seen from the work shown. Rounding of decimals is consistent. | Equation is close. The method is correct, which cannot be seen from the work shown. Minor errors account for the incorrect equation. | Equation is incorrect, but the error can be found in the work shown. | There is an equation, but no work is shown so errors or method cannot be found. |
| Calculator Check of the Equation | Verifies the resulting calculator equation, scatter plot, and line of fit against the correct equation. Includes an explanation of results. | No student explanation given. | The equations are reasonably close. | Equation does not match. |
| Conclusions, Problems, and Predictions | Problems are solved correctly. Conclusions and predictions are reasonable and logical; reasoning is used to support these conclusions. | Problems are solved correctly. Conclusions and predictions are appropriate but may be incomplete or not supported with complete reasoning. | Problems are solved correctly. Conclusions and predictions are given. May not be supported with sufficient reasons. | Problems, conclusions, and predictions are given but may be incorrect, incomplete, or have no reason stated. |

# *We Challenge Orville — Middle Level #1*

Here is an example of a quiz used for an Algebra I class.

**Authentic Task Quiz — Line of Best Fit**

The following is a list of fast food items, their grams of fat, and their calorie count.

| Item | Grams of Fat | Calories |
|---|---|---|
| Burger King Whopper | 33 | 584 |
| McDonald's Big Mac | 34 | 572 |
| Wendy's Big Classic | 28 | 500 |
| Arby's Roast Beef | 19 | 365 |
| Hardee's Roast Beef | 17 | 338 |
| McDonald's Filet-O-Fish | 23 | 415 |
| Arby's Chicken Breast Sandwich | 32 | 567 |
| Burger King's Chicken Tenders | 12 | 223 |
| Hardee's Chicken Filet Sandwich | 20 | 431 |
| Kentucky Fried Chicken (2 piece) | 31 | 460 |
| Kentucky Fried Chicken Nuggets | 17 | 281 |
| McDonald's Chicken McNuggets | 18 | 286 |
| Wendy's Chicken Filet Sandwich | 24 | 479 |

1. Make a table and draw a graph of the data.

2. Draw the line of best fit.

3. Write the equation of the line of best fit.

4. Answer the following:
   a. If Circle J has a chicken filet sandwich with 20 grams of fat, what would you predict its calorie count to be?

   b. If Jack and Bev have a deluxe hamburger with 500 calories, what would you predict the fat grams to be?

   c. What conclusions can you make from your graph?

# *We Challenge Orville — Middle Level #1*

**WE CHALLENGE ORVILLE - Student Guide**

**Procedure:**

A. Pick one of the 4 brands of popcorn to perform this experiment.
B. Count out 20, 40, 60,...200 kernel samples.
C. Estimate how many kernels you think will pop and record your estimate in the table.

Brand:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of Kernels | | | | | | | | | | |
| Estimated Number Popped | | | | | | | | | | |
| Actual Number Popped | | | | | | | | | | |

D. Pop each sample of popcorn, counting the number of popped kernels. (Hint: Count the number of unpopped kernels and subtract to find the number of popped kernels.)
E. Record the data in your table.
F. Make a scatter plot of the data.
G. Find the line of best fit.
H. From your graph, determine how many kernels will pop out of 500 kernels.
I. Explain how you found your answer for H. (Use a picture or diagram, write a paragraph, present a mathematical explanation, or use an oral report.)
J. Make a class line graph to compare the results of the different brands.
K. Draw your line of best fit on the class graph. Use a different color for each brand and identify it on the graph.
L. Determine from the class graph which brand you think is best. Justify your answer. (Use a picture or diagram, write a paragraph, present a mathematical explanation, or use an oral report.)
M. The cost for the popcorn was:

| Brand of Popcorn | Price | Amount |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

N. Does this change your opinion from question L? Justify your answer.

# *Rocks and Rubberbands — Middle Level #2*

**Materials\Supplies:**
Sandwich bags with wide rubber bands attached
Sets of 10 similarly sized, washed rocks
Meter sticks
Graphing calculators

**Topic Strands:**
Force and Motion
Force and Motion
Algebraic Topics

**Conceptual Threads:**
Energy
Patterns of Change
Connections

**Process Skills of Learning:**
Inferring   Interpreting Data   Measuring
Modeling   Predicting

**Why** (Purpose/Objective of the lesson):
To observe properties of energy and elasticity and to construct linear equations.

**How** (Procedure of the lesson):
1. Bungee jumpers video/discussion provides a good anticipatory set.
2. Teacher jots down students' initial reactions, experiences, and comments about applications of bungee cords.
3. Have students follow the directions provided on the Data Sheet for this activity.
4. Teacher facilitates discussion on what would happen if you used different sizes of rocks, or different sized rubberbands, why the graphic points are not exactly linear, and the proportionality constant of Hooke's Law.

**For Your Information** (Background information for the lesson):
1. Within the limits of each rubber band, the amount of stretch of the rubberband will be directly proportional to the force. This is known as Hooke's Law.
2. A graph of the length of the rubberband versus the number of rocks will be linear, until the limits of the rubberband are reached and the rubberband breaks. The slope of this line will be the constant in Hooke's Law and the y intercept will be the length of the stretched rubberband.
3. Each type or size of rubberband will have a different constant for Hooke's Law. The points may not be exactly linear due to variation in the size of rocks.
4. Other factors that may affect the experiment are weight of the object and height of object. Also the height of a jump affects the acceleration due to gravity and length and width of elastic.
5. Some South American tribes use land diving as a rite of passage to manhood.

# *Rocks and Rubberbands — Middle Level #2*

**Suggested Instructional Strategies:**
1. Group discussions and cooperative groups.
2. Use other student expertise for demonstration of graphing calculators.

**Additional Activities** (Extensions):
1. This topic can be related to springs, elasticity, suspension systems in vehicles and furniture; earthquake-proof engineering or safety standards in cars; bungee jumping used in advertising for automobiles and soft drinks; trapeze; crane cables; and mountain climbing.
2. Your friend makes a bet that you can not make a bungee jump. You need to make a scale model of yourself using a breakable object like an egg or water balloon, jumping from the top of a door to within 5 cm of the floor. String can be used rather than rubber bands to simulate South American land divers.
3. Use a calculator to determine the line of best fit.

**Possible Assessment Ideas:**
1. Successful completion of the activity, focusing on the ability to extrapolate and graph. A sample performance rubric for "Rocks and Rubberbands" is included.
2. Student ability to apply knowledge to new graphing situations.
3. Peer and self evaluation.

# *Rocks and Rubberbands — Middle Level #2*

**Sample Performance Rubric:**

| Criteria | Proficient | Basic | Needs Work |
|---|---|---|---|
| Cooperative work | Works well with group, offering suggestions and listening to suggestions of others. | Works well with group most of the time, offering occasional suggestions and listening to occasional suggestions. | Does not work well with group, offering few suggestions and not listening to suggestions of others. |
| Sets up a valid experiment, controlling variables | Sets up a valid experiment and controls all variables except the one tested. | Sets up a valid experiment and controls most variables. | Has difficulty setting up a valid experiment and controlling the proper variables. |
| Extrapolation | Accurately predicts the length of rubberbands as weights are added. | Accurately predicts the length of rubberbands as weights are added some of the time. | Can not accurately predict the length of rubberbands as weights are added. |
| Graphing | Able to accurately label and graph the results. | Able to accurately graph, but had trouble labeling the graph. | Had difficulty graphing and labeling the graph. |

# *Rocks and Rubberbands — Middle Level #2*

## Data Sheet

Names: ______________________ ______________________

______________________

Identify within your group who will do the following:

Measure data ______________________

Record data ______________________

Hold rock ______________________

1. Describe the purpose of this activity.

2. Place the first rock in the bag and measure the length of the rubber band. Record your data in the data table. Repeat this process until you have data for the first four rocks.

3. Construct a graph which represents this relationship. Label the axis and indicate increments used.

4. Predict what you think will happen when you add rock number five, using the process of extrapolation.

5. Add rock number five and record your data. Continue to add rocks, record, and graph the data.

**Data Table:**

| **Rocks** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Length** | | | | | | | | | | |
| **Change in Length** | | | | | | | | | | |

6. What patterns do you see?

______________________

______________________

# *Rocks and Rubberbands — Middle Level #2*

7. What happens as the number of rocks increases?

___

___

8. Why are the points not all in a straight line?

___

___

9. If you had three rocks and a smaller rock, what do you think the length might be?

___

___

10. If you had 12 rocks, what do you think the length might be? Explain you answer.

___

___

___

11. What do you think the length of the rubber band would be with no rocks? (Find your answer by looking at the data or the graph. Then check your answer by measuring the length of the rubber band with no rocks in the bag).

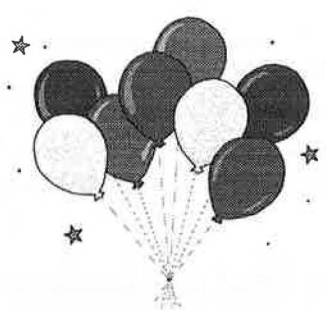
    length from graph or data ________________
    measured length ________________________ (This number is one of two special numbers).

12. Determine the average change in length for each rock added. Show below how you found your answer.

    Answer: ________________________ (This is a second special number).

# *If You Smoke, You Croak — Middle Level #3*

**Materials\Supplies:**
Balloons
Centimeter Tapes
Liter Containers
Non-smoking Posters
Respiratory System Poster



**Topic Strands:**
Cells and Heredity
Spatial Relationships
Data Analysis
Algebraic Topics

**Conceptual Threads:**
Systems and Interactions
Connections
Technology
Connections

**Process Skills of Learning:**

| | | |
|---|---|---|
| Connecting | Interpreting Data | Measuring |
| Modeling | Questioning | Reasoning |

**Why** (Purpose/Objective of the lesson):

1. To relate the volume of spheres to lung capacity.
2. To discover connections between algebraic concepts of slope, linear functions, and power functions; and the geometric concepts of circle, sphere, volume, and pi.
3. To understand, interpret, and appreciate data discrepancies.
4. To investigate the effects of different variables on lung capacity.

**How** (Procedure of the lesson):

1. Arrange "No Smoking" posters in the room to stimulate student interest.
2. Examine animal lungs obtained at local meatpacking plant, butcher, or veterinarians.
3. Teacher records initial thoughts and comments from students about lung capacity and the effects of smoking.
4. Discuss and estimate the volume of one's lungs in liters.
5. Have students exhale normally and then force the residual volume out into a balloon. Have partners measure the circumference of the balloon and calculate its volume in cubic centimeters. Record three trials and average. Record on the classroom chart.
6. Have each student take the biggest breath and force all the air into the balloon. Measure the circumference of the balloon and calculate the volume in cubic centimeters. Record three trials and average. Record the average on the classroom chart.
7. Graph the results (diameter on x-axis and circumference of balloon on y-axis, or plot diameter of balloon on x-axis and volume on y-axis).
8. Have students calculate the mean, mode, and median for both total capacity and residual capacity.
9. Convert cubic centimeters to liters and compare to liter containers. Graph the volume versus the diameter.
10. Compare the results of smokers, to non-smokers, and asthmatics.

# *If You Smoke, You Croak — Middle Level #3*

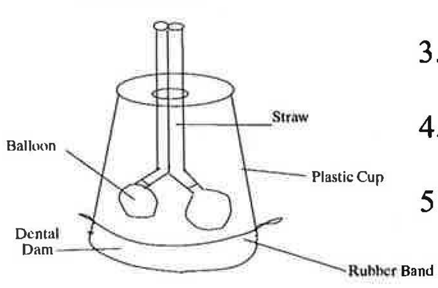
11. Debrief by discussing factors that can cause variability in data and how the experiment could be altered to minimize these kinds of errors.
12. Collect community data on the effects of the anti-smoking campaign, e.g., no-smoking areas, designated smoking areas, non-smoking lodging.

**For Your Information** (Background information for the lesson):
1. Use soft, easy-to-blow balloons.
2. Smoking statistics can be obtained from the American Cancer Society.
3. Facts you will need to know:
   a. The slope of the line for diameter versus circumference graph equals pi.
   b. The graph of volume versus diameter is a curved line.
   c. Conversion from cubic centimeters to liters is to divide by 1000
4. Students with respiratory problems such as asthma must receive special consideration.
5. If you use the animal lung station, the activity should be prefaced by educating students that the lungs do not inflate by blowing air in. Due to the lack of a functioning diaphragm, lung inflation must be aided by pushing air into the lungs. Community connections to "Recussa Annie" can be made here.

**Suggested Instructional Strategies:**
Use cooperative learning to investigate and solve problems. If possible, lab stations could be set up and covered by mentor upper-level students.

**Additional Activities** (Extensions):
1. Discuss the minutes off one's life for each cigarette smoked. This ties in well with DARE Program.
2. A model of a lung machine makes a good anticipatory set. See diagram.

MODEL LUNG




3. Research diseases that could affect lung capacity, such as stroke or heart attack.
4. Circumference can be measured with balloons filled with one breath, two breaths, three breaths.
5. Measure the time it takes for air to flow out of the balloon (flight time). Graph diameter versus flight time, or volume versus flight time. This works well with a unit on respiration. For instance, the importance of residual volume in life-threatening situations and CPR could be explored.
6. Current issues such as smokers' versus nonsmokers' rights, effect of environmental pollutants on breathing, and subsidies to tobacco

# *If You Smoke, You Croak — Middle Level #3*

farmers (including historical, economic and cultural aspects) could be debated.

7. Research effects of exercise, smoking, age, sex, and second-hand smoke on lung capacity.
8. Research tobacco and its use in cultures and ceremony.
9. Do more statistical data analysis such as standard deviation and chi square test.
10. Set up stations with pig lungs, videos with smoking, making lung machines from cups and balloons, etc.
11. Research well-known people who have died as a result of complications due to smoking.

**Possible Assessment Ideas:**

1. Observe involvement in group sharing of questions.
2. Examine graphs and classroom charts.
   a. Look at the graph of diameter versus circumference. The points form a straight line (note that (0,0) is a point on the line). The line serves as a guide to see if calculations were done correctly. Draw a line through the points or use best fit line on calculator. The slope of the line will be close to pi.
   b. Look at the graph of diameter versus volume. If residual volume was not used it looks like a straight line ((0,0) is a point on the curve). The curve looks like a parabola but is actually a cubic because radius is cubed.
3. Use the following checklist to measure students' understanding of lung capacity.

# *If You Smoke, You Croak — Middle Level #3*

| Checklist Item | Yes | No |
|---|---|---|
| 1. Works well with partner all of the time. | | |
| 2. Can fully explain lung capacity. | | |
| 3. Can demonstrate how to measure lung capacity. | | |
| 4. Can calculate volume of balloon with ease and 100% accuracy. | | |
| 5. Can fully explain effects of smoking or residual lung capacity. | | |
| 6. Can fully explain several ways disease affects lung capacity. | | |
| 7. Can calculate averages, means, and medians with 95% accuracy. | | |

## Checklist Criteria

| Criteria | Proficient | Basic | Needs Work |
|---|---|---|---|
| Cooperative Work | Works well with partner all of the time. | Works well with partner more than half the time. | Does not work well with partner. |
| Understanding Total Residual Lung Capacity | Can explain fully lung capacity and demonstrate how to measure it using the balloon. | Can give basic information on lung capacity and has some idea how to measure it using the balloon. | Has difficulty explaining and/or measuring lung capacity. |
| Mathematical Calculations Concerning Volume | Can complete problems for calculating volume of the balloon with ease and 100% accuracy. | Can complete problems for calculating volume of the balloon with little help and at least 75% accuracy. | Has difficulty completing problems for calculating volume of the balloon without help and/or is not at least 75% accurate in calculations. |
| Understanding Effects of Smoking on Residual Lung Capacity | Can fully explain the effects of smoking on residual lung capacity. | Can give very basic information about smoking and residual lung capacity. | Has difficulty explaining any effects that smoking might have on lung capacity. |
| Extending Learning to Things That Affect Lungs Other than Just Smoking | Can fully explain the way more than one disease affects lung capacity. | Can give basic information on the way at least one disease affects lung capacity. | Has difficulty explaining exactly how lung capacity is affected by other conditions. |
| Other Mathematical Calculations | Can calculate averages, means, and medians with ease and 95% accuracy. | Can calculate averages, means, and medians with little help and at least 75% accuracy. | Has difficulty calculating averages, means, and medians without aid or at 75% accuracy. |

# *If You Smoke, You Croak — Middle Level #3*

Estimate the volume of each student's lungs in liters (think of a two-liter pop bottle).

Person 1 ____ Person 2 ____

Students will explore their lung volume. Each student will need a partner to fill in the following information.

| | Record Circumference | Record Flight Time | Calculate Diameter | Calculate Volume of Lung |
|---|---|---|---|---|
| **Residual Lung Volume** | | | | |
| **Lung Volume** | | | | |
| **Balloon with Two Breaths** | | | | |
| **Balloon with Three Breaths** | | | | |

**Circumference** is equal to diameter times pi.

**Volume of a sphere** is 4/3 times pi times radius to the third power.

**Residual Volume** — Exhale normally and then force the remaining air from your lungs into the balloon. Measure the circumference of the balloon using the tape measure (or string).

**Lung Volume** — Take as large a breath as possible. Exhale as much air as possible into the balloon. Measure the circumference of the balloon using the tape measure.

**Two Breaths** — Fill the balloon with two breaths of air.

**Flight time** is measured from when the balloon is released until the balloon runs out of air (not necessarily when the balloon hits the floor). This may be enhanced by taping a straw on the opening of the balloon.

**Graphing possibilities**
1. Diameter versus Time
2. Circumference versus Diameter
3. Volume versus Diameter
4. Volume versus Time

# *Einie, Meinie, Minie, MOW — Middle Level #4*

**Materials\Supplies:**
Popsicle sticks
String
Meter sticks
Grass plot
Nielson Rating posters

**Topic Strands:**
Diversity
Spatial Relationships

**Conceptual Threads:**
Systems and Interactions
Estimation

**Process Skills of Learning:**
Communicating, Connecting, Inferring, Measuring, Observing, Patterning

**Why** (Purpose/Objective of the lesson):
To experience random sampling by using grass plants to estimate populations and to investigate the effects of variables on population.

**How** (Procedure of the lesson):
1. Have student estimate the number of grass blades in an entire area and share their reasoning strategies.
2. Each group will mark off three 100 square centimeter areas of lawn using popsicle stick stakes and string.
3. Students count the blades of grass in each marked off area and record.
4. Students average the three results.
5. Students determine the area of the entire lawn and number of blades of grass using their sample. Record.
6. Students compare their estimates, strategies, and graphing results.
7. Teacher facilitates discussion that relates population samples in various environments, population discrepancies, and influencing factors.
8. Do a population sample of bugs, diseased plants, or a specified weed.

**For Your Information** (Background information for the lesson):
1. Before beginning the investigation, the class must decide whether to count the grass as blades or plants so data can be compared and contrasted.
2. Research can be done and guest speakers secured regarding real-world applications of random sampling; such as animal populations, seed companies, insurance companies, or food industry location sampling.
3. Astronomers use sampling for density of bodies in the universe, park rangers for animal densities, farmers for chinch bugs, and insurance adjustors for crop damage.

# *Einie, Meinie, Minie, MOW — Middle Level #4*

**Suggested Instructional Strategies:**
Encourage students to experiment and investigate variables that affect population growth. Use cooperative groups and group discussions to facilitate student learning.

**Additional Activities** (Extensions):
1. Use different geometric shapes to determine the 100 square centimeter areas.
2. Explore variables such as light, temperature, and aeration on grass germination and growth.
3. Compare data on two similar plots, such as fertilized and unfertilized.
4. Do a census of several blocks near the school, extrapolate to city population, and compare to recent census figures.
5. Sample shaded areas and areas of high foot traffic to show the impact on the environment.
6. Determine other nature populations, such as owls.
7. Investigate biomass and biodiversity.
8. Have students write a story from the point of view of an ant.
9. Work with students on scientific notation.
10. Repeat the investigation with samples from other areas that are affected by different variables such as traffic, light, fertilizer, aeration, species of grass.
11. Discuss how adding a multilevel apartment building affects the surrounding environment (parking, neighborhood traffic, etc.)

**Possible Assessment Ideas:**
1. Examine student graphs of results.
2. Observation of student involvement in group sharing of strategies.
3. Successful completion of data analysis worksheet.
4. Pose one of these problems to the students and have them design strategies for solving it.
   a. Select an animal species and estimate its population in a given area.
   b. Determine how many blades of grass are on the football field.

# *Einie, Meinie, Minie, MOW — Middle Level #4*

## Data Analysis
### Grass Plots Follow-through

1. There is a finite number of grass blades on the football field. Why did the class arrive at different answers?

2. Why did the answers range so far in number from one another?

3. What would you accept as the real number of grass blades on the field and why?

4. What suggestions do you have to make this counting method more accurate?

5. There were multiple methods to solve this problem. Demonstrate at least two and put a star next to the method you feel is more efficient. Explain the reasons for your choice.

6. What are the real-world examples where this sampling method might be used to do data analysis?

7. What might be some factors that would influence the number of grass blades that would be counted in another grass plot?

8. Did you use mental math to calculate? If so, which exact calculations?

9. Did you and your partner(s) work well together? Why or why not?

# *Is Your Body Golden? — Secondary Level #1*

**Materials/Supplies:**
Meter sticks/rulers
Metric tape

**Topic Strands:**
Patterns and Functions
Diversity

**Conceptual Threads:**
Reasoning and Logic
Patterns and Change

**Process Skills of Learning:**
Connecting Inferring Measuring Patterning

**Why** (Purpose/Objective of the lesson):
To discover the existence of patterns in common experiences and in nature.

**How** (Procedure of the lesson):
1. Form cooperative groups of 3-4.
2. Have each group make a table which includes the following lengths:
   a. index finger and distance from fingertip to large knuckle
   b. arm and distance from elbow to fingertip.
3. Calculate the ratios and record them in a table for each pairing in step #2.
4. Construct a class table of the two ratios.
5. Discuss the outcomes and try to find another pair of body parts whose lengths have the same ratio. Other possible golden ratios that may be investigated are height to navel height, height to distance from hip to kneecap, height to arm span, height to foot length, hand length to foot length, forearm to foot length, wrist diameter to neck diameter, the base of the thumb diameter to wrist diameter, the first two joints of the index finger on the dominant hand to nose length.
6. Brainstorm students' ideas of how and why these ratios may be considered "Golden."
7. Have students research and share numerical patterns found in art, music, nature, architecture, and mathematics.
8. Find a living organism (such as a grasshopper, cat, cow, or frog) and measure distances and calculate ratios trying to find mathematical patterns.
9. Find five examples in nature whose lengths exhibit mathematical patterns.



**Another Approach:**
Students completing the structured activity described in #1–9 will limit their explorations to the questions asked by the teacher. They will probably not generate their own questions and class members will all produce similar results. The students will focus on completing the activity. To reduce these limitations and allow students to explore, discover, and develop their own method to solve a problem, a more open-ended approach may be used. Using an inquiry/problem-solving

# Is Your Body Golden? — Secondary Level #1

strategy will produce a wide range of products as students define their problems differently and use different strategies to reach their conclusions. This method challenges the students to reach their potential using skills which have been developed in other activities.

**A Student-Centered Approach:**
1. Give students a bone such as a femur and estimate the size of the animal it came from.
2. Examine anatomical models to determine if they are properly proportioned.
3. Dissect owl pellets. Use number patterns to investigate homologous structures.
4. Investigate the surface area/volume relationship between organisms with exoskeletons compared to organisms with endoskeletons.

**For Your Information** (Background information for the lesson):
1. There is a *Math Vantage* videotape, available through the ESU or Nebraska Department of Education, on the Fibonacci sequence and the golden ratio.
2. Teacher may need to review computation of ratios before using this activity.
3. Consult math books and/or encyclopedias for background knowledge. The ancient Greeks considered the golden ratio the most pleasing in architecture. The golden ratio exists in the architecture of the Parthenon. A German Psychologist connected the golden ratio to the human body. Body part ratios will vary between children and adults
4. This activity is adapted from the Special Project "The Golden Ratio" on pages 475-480 in *Discovering Geometry* by Michael Serra, Key Curriculum Press.
5. *Donald in Mathemagicland* is a good video for providing examples of the Golden Ratio in a cartoon format.
6. Number patterns may be found in playing cards, credit cards, nature (the arrangement of leaves on a stem and their relationship to one another, the growth and development patterns of certain structures such as pine cones, pineapples, flower petals, the pattern of growth of the chambered nautilus, snails, sand dollars, and starfish), music, architecture, and art. More information may be found in *Favorite labs from Outstanding Teachers Vol. 2* (National Association of Biology Teachers (NABT), in the activity called "Fibonacci Numbers and Biological Patterns."

8. Recommended reference: *Fascinating Fibonacci - Mystery and Magic in Numbers*, Dale Seymour Publications, 1987, by T.H. Garland.

# *Is Your Body Golden? — Secondary Level #1*

**Suggested Instructional Strategies:**
1. Use of cooperative learning.
2. Teacher is a facilitator.
3. Use of investigation and reflective thinking
4. Community resources should be used to discover number patterns in nature.

**Additional Activities** (Extensions):
1. Find other occurrences of the Fibonacci sequence and the golden ratio.
2. Computer spreadsheets may be used to analyze the data.
3. Research the connections between insect plagues and surface area/volume relationships between organisms with exoskeleton and organisms with endoskeletons.

**Possible Assessment Ideas:**
1. Assess students' completion of authentic tasks. See attached rubric.
2. Peer and self evaluation of performance as cooperative learners. Each student should evaluate self and members of their group with the following checklist:

**Checklist for Cooperative Learners:**

| Yes | No | |
|---|---|---|
| ___ | ___ | Provides encouragement |
| ___ | ___ | Contributes ideas |
| ___ | ___ | Helps process ideas |
| ___ | ___ | Participates in discussions |
| ___ | ___ | Does fair share of work |

Comments :

# *Is Your Body Golden? — Secondary Level #1*

**Authentic Task:** You have been hired by Broken Arrow Shirt Company to make shirts for men with 15" necks. Your job is to determine what length of sleeve you need to make for these shirts.

Rubric for the task

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Measurement | Uses correct instruments to measure. Applies appropriate units to each measurement. | Uses correct instruments to measure. Needs assistance to apply appropriate units. | Uses inappropriate instruments to measure. |
| Inferring | Interprets data. Uses table to find five similar ratios. | Interprets data. Uses table to find some similar ratios. | Does not interpret data. |
| Connecting | Finds most common ratios. Predicts other comparisons that will give this ratio. | Finds common ratios. Makes wrong additional comparisons. | Does not find ratios. Makes no other correct comparisons. |
| Math Concepts | Correctly calculates all ratios. | Correctly calculates some ratios. | Does not make correct calculations. |
| Connecting: Relationships | Relates objects, data, and procedures in one situation with those in another situation. | Misses a critical relationship between two situations. | Identifies similar objects, data, or procedures in two situations. |
| Connecting: Applications | Applies ideas in new or unique ways. | Applies ideas using given examples. | Restates application of ideas. |

# *Can Can — Secondary Level #2*

**Materials/Supplies:**
Variety of containers
Rulers
Scissors
Graduated cylinders
Rice, corn, or beans

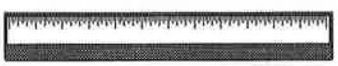
**Topic Strands:**
Spatial Relationships
Spatial Relationships
Interdependence

**Conceptual Threads:**
Problem Solving
Estimation
Systems and Interaction

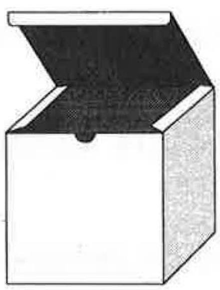
**Process Skills of Learning:**
Communicating Connecting Problem Solving Reasoning

**Why** (Purpose/Objective of the lesson):
To apply area and volume concepts in an investigation to determine the most efficient/cost-effective use of materials in designing a closed container.

**How** (Procedure of the lesson):
1. Set up variety of containers. Students predict how much each container will hold.
2. Teacher records student opinions about most efficient and/or cost effective container.
3. Students select and measure three containers of their choice. Apply formulas and compare with actual capacity of container.
4. Teacher can provide or students may generate a checklist of expectations to be used for assessment purposes (see sample below).



**Checklist for Evaluation** (refer to rubric for criteria)
a. Develop definitions for "most efficient"/"cost-effective"containers.
b. Formulate appropriate questions and predict answers.
c. Make correct measurements in appropriate units to support conclusions.
d. Construct a container with the correct capacity.
e. Explain solutions in writing or orally.
f. Present solutions to the class.
g. Use appropriate volume and surface-area formulas.
h. Compute ratios of surface areas to volume.
i. Suggest other applications or extensions of the concept.



5. Teacher provides 250 ml of a substance (rice, beans, or corn). Students design a container to hold that amount of material with greatest efficiency or cost effectiveness.
6. Students construct a container from materials provided by the teacher.
7. Compile data from containers constructed in step five.
8. Share outcomes and strategies with other groups. Discuss surface areas and measure for each container.

# *Can Can — Secondary Level #2*

9. Try to reach consensus on the most efficient/cost-effective design.
10. In cooperative groups, research and select an environment and design a human container (dwelling) which is most efficient for that environment. Make a scale drawing and a written or oral report of each group's design.

**For Your Information** (Background information for the lesson):
1. Review units of measurement for area and volume.
2. Knowledge of area and volume formulas for solids would be helpful.

| Solid Type | Volume | Surface Area |
|---|---|---|
| prism | area of base times height | sum of area of faces |
| cylinder | area of base times height | $2\pi r^2+2\pi rh$ |
| pyramid | area of base times height/3 | sum of area of faces |
| cone | area of base times height/3 | $\pi r$ (slant height) + $\pi r^2$ |
| sphere | $[4\pi r^3]/3$ | $4\pi r^2$ |

3. Students should be provided a list of the cost of materials if they are to calculate cost effectiveness.
4. Possible anticipatory sets:
   a. Make a foil mold of an ear of corn. Estimate how much of the mold will be filled by the shelled corn. Shell the corn and return to the mold. The corn without the cob should fill the mold.
   b. Using a balance scale, balance one large potato with several smaller ones. Time students as one person peels the larger potato and another peels the smaller ones, keeping the piles of peelings separate. Find the mass of each pile of peelings. Compare the separate times and masses. Examine the relationship between surface area and volume.
5. Explorations of human dwellings may include igloos, tepees, sod houses, solar homes, yurts, subterranean homes, dugouts, adobe houses, cliff dwellings, berms, or lodges.
6. Consult the English department for oral/written assessment.

**Suggested Instructional Strategies:**
Group discussions, cooperative groups of two or three, modeling.

**Additional Activities** (Extensions):
1. Research consumer preferences and marketing techniques as they pertain to product design.

# *Can Can — Secondary Level #2*

2. Students can determine whether a manufacturer has made the most economical packaging for their product.
3. Explore relationships of surface area to phenomena; i.e., wood splinters ignite easily while wood chucks do not; Alka-Seltzer tablets react with water more quickly when crushed; the relationship between cellular surface and volume.
4. Communicate findings to packaging companies.
5. Explore or research animal adaptations related to metabolism — surface area and volume in terms of retention and dispersion of heat. Stephen J. Gould has an interesting essay about this.
6. Make scale models of the dwelling designs.
7. Look at the energy efficiency of the dwellings.
8. Relate how the construction materials of their home connect to their physiological needs.
9. Invite a community member to discuss construction or engineering as a career.
10. Read and discuss *Loghouses in the Northwest USA*.

**Possible Assessment Ideas:**
1. Evaluate usability of container/dwelling. Share findings and supporting evidence with classmates.
2. See attached rubric for efficient container.

**Authentic Task**: You are a package designer for the Whole Earth Wild Rice Company. Your task is to design the most efficient, cost-effective package which maintains the quality of the rice and will hold a specified volume of rice. A written and oral presentation of your success and results needs to be given to the production managers. The managers will also want a model of the final package and demonstrated proof that the given volume will fit in the package.

# *Can Can — Secondary Level #2*

**Rubric for Checklist** (making an efficient container):

| Processes/ Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Questioning, Inferring, Interpreting, Reasoning | A number of quality questions developed involving the effect of one variable on another. Prediction of answers given and justified. Conclusion justified by referring to all work. Gives ecological impact of material used in package. | Questions not stated. Prediction not completely justified. Complete conclusion given but not justified. Ecological impact analysis unclear. Sources not given. | No questions, no prediction, incomplete conclusion, and ecological impact not given. Sources not given. |
| Measuring | Measurements are correct and are used to validate calculations or solutions. | Some measurements are incorrect or solutions are not validated using measurements. | Measurements are made but not used; most measurements are incorrect. |
| Modeling | Neatly constructed container, able to hold specified volume; demonstrates **efficient** packaging. | Constructed to hold most of specific volume. Some efficiency in packing evident. | Poorly constructed container, does not pack well, too small or too large for designated volume. |
| Communicating | Uses all symbols and terms correctly. Steps of methods explained in detail. Organized. | Uses symbols and terms with some errors. Gaps in explanation of method. Some organization is evident. | Uses symbols with some errors but no terms. Does not explain methods. Unorganized. |
| Inferring: Relevance of mathematics used | Demonstrates application of use of volume formula, uses surface area formula, and makes a ratio of surface area to volume. | Demonstrates application of use of volume formula and surface area formula but does not make a ratio of surface area to volume. | Demonstrates lack of application skills of using volume formula and surface area formula and ratio of surface area to volume. |
| Inferring: Recognition of the relevance of findings | Communicates a new extension of the problem. | Communicates a relationship to "previous experience." | Lack of ability to communicate relationship to other problems. |

# *The Race is On — Secondary Level #3*

**Materials/Supplies:**
Electric fan with variable speeds
8 1/2 x 11 paper
Drinking straws
Wooden beads
¼" pins
Staples
Tape
Timing device such as ticker tape, photo gate, or video
Camera with motion detector
CBL (calculator based lab)

**Topic Strands:**
Force & Motion
Force & Motion
Algebraic Topics
Advanced Topics (Calculus)

**Conceptual Threads:**
Energy
Patterns of Change
Connections
Problem Solving

**Process Skills of Learning:**
Interpreting Data    Modeling    Problem Solving

**Why** (Purpose/Objective of the lesson):
To design wind-powered vehicles and compare the effects of different variables of design on velocity.

**How** (Procedure of the lesson):
1. Students should maintain a progressive journal throughout this activity. See attached checklist.
2. View selected scenes from the video "Wind" to introduce the topic of wind-powered vehicle design.
3. Students generate examples of resistance and friction. Have students gather information on aerodynamics and use of wind. Brainstorm effective characteristics of sail designs.
4. Pairs of students will design a vehicle from the given materials.
5. Construct a wind-powered vehicle using 1 piece of 8.5" by 11" paper, 8 straws, 4 beads, and 20 straight pins. All material must be used on the vehicle.
6. Vehicle will be powered by a fan.
7. Determine the velocity of the vehicle by using a ticker tape timer, photo gate, or video camera.
8. Conduct three trials. Determine the trial with the highest velocity.
9. Redesign the vehicle (student may incorporate other designs).
10. Retest the vehicle.
11. Simulate a race to determine the fastest vehicle. Then line up the vehicles in order to analyze the variables affecting velocity.
12. Record distance and time. Make a cumulative-distance/cumulative-time graph. Use graph to find:
    a. the average velocity (slope between 2 points), and
    b. the instantaneous velocity (slope of the tangent line at a chosen point).

**For Your Information** (Background information for the lesson):
1. Beads must spin smoothly around straws used for axles.
2. The first derivative of the position function is the formula for the instantaneous velocity.

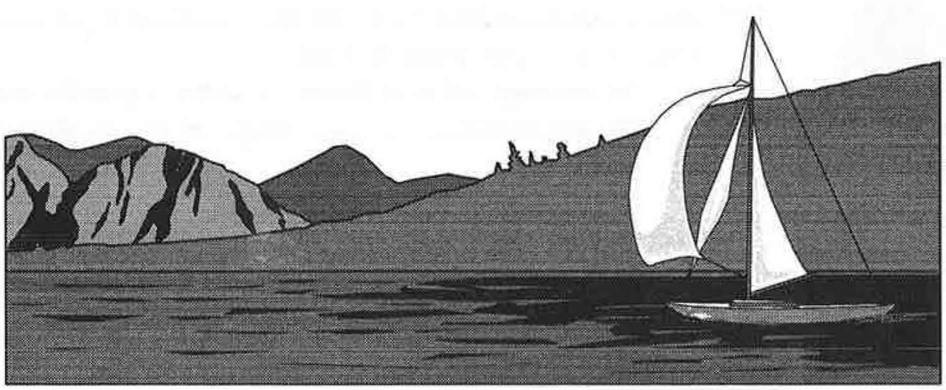
# *The Race is On — Secondary Level #3*

**Suggested Instructional Strategies:**
1. Two persons cooperatively design a wind-powered vehicle.
2. Modeling and simulation are exemplified in this activity.

**Additional Activities** (Extensions):
1. Design an alternative powered vehicle such as solar, mechanical, or chemical.
2. Research momentum and potential and kinetic energy.
3. Construct a ramp to investigate variables such as the slope and length of the ramp.
4. Students may relate their research results to automobile design by obtaining information from local dealers and presenting to class.
5. Investigate fluid flow around regular geometric shapes.

**Possible Assessment Ideas:**
A progressive journal will be used to assess student performance. See checklist.

**Checklist for Progressive Journal**
1. The record should be written, oral, or audio/visual.
2. The task should be defined.
3. All handouts are included in the journal.
4. The journal is organized by date.
5. The journal contains a sketch of all the designs.
6. All changes in design are reported (may be pictorial, written, or oral). Include what was changed and why it was changed.
7. Report information and explain how this influenced the design.
8. All data are recorded.
9. Analysis of data contains data, graph, average and instantaneous velocity, and conclusion.
10. How did each of the team members function each day (self- and peer-assessment)?
11. Class discussions are summarized.



# Appendix

# *Elementary Level — Sample Rubrics for Process Skills*

## Classifying

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Sort/Group | Recognizes and creates complex groups using more than one attribute; can classify more than one attribute at a time. | Recognizes attributes and creates simple groups. | Randomly manipulates objects; haphazardly sorts/groups. |
| Matching | Identifies needed information; can see and explain connections. | Can recognize similar attributes. | Randomly manipulates objects; makes matches haphazardly. |
| Communication of Attributes | Communicates results clearly and logically; can communicate ideas in several forms (orally, in writing, drawings, graphs). | Can use simple explanations to communicate ideas. | Cannot explain work or strategy adequately. |

## Communicating

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Conveying Information | Can communicate ideas in three or more forms (orally, written, drawings, graphs). | Can communicate ideas in one or two forms (orally, written, drawings, graphs). | Difficulty in expressing ideas. |
| Data Collection | Accurately and completely collects and organizes data. | Collects and organizes data with some inaccuracy. | Data not completely collected or is inaccurately organized. |
| Explaining Thinking | Explains thinking process using details that explain or support the idea or topic; applies thinking process to make ideas clear or concise. | May need assistance or prompts to explain thinking process; uses details that explain or support the idea or topic. | Withdraws from discussion; unable to explain thinking process; no details to show understanding. |

## Connections

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Extensions | Explores and relates ideas. | Recognizes similar situations. | No attempt to relate ideas. |
| Application | Extends connections to "real" world. | Makes connections to other subject matter. | Cannot apply ideas. |

# *Elementary Level — Sample Rubrics for Process Skills*

## Interpreting Data

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Makes Inferences | Carefully considers all information; can analyze components; sees many connections within data. | Does not consider all possibilities; examines components with some inferences; sees some connections with data. | Draws minimal information from instruction; does not show initiative in analysis; recognizes few connections within data. |
| Communicating | Designs tool for communicating; reports facts and insightful information. | Conveys information by reporting basic facts. | Rarely offers information; cannot design tool for conveying information. |
| Drawing Conclusions | Interprets with clarity and creativity; shows initiative in summarizing; able to extrapolate beyond known data; makes highly accurate predictions; solutions are reasonable. | Interprets information adequately; can draw some conclusions from data, unable to extrapolate beyond known data; uses good judgment for some predictions; solutions are reasonable with minimal flaws. | May answer simple questions if prompted; makes faulty assumptions; cannot draw conclusions; makes faulty predictions, if at all; solutions are unreasonable. |

## Measuring

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Uses Standard and Non-Standard Measurement with Accuracy | Able to measure using standard and non-standard units to fractional increments. | Able to measure using standard and non-standard units. | Unable to measure using standard and non-standard units. |
| Selection/Use of Measuring Tool | Selects appropriate measurement units for task and demonstrates appropriate use of measurement equipment/tool. | Can select measurement unit and use measurement tool, but it is not the most appropriate unit or tool for the task. | Recognizes differing measurement units but is unable to apply them appropriately to the tasks; can use measurement tool with assistance. |
| Solves Problems Using Measurement | Develops procedures/ formulas to solve problems related to measurement. | Solves problems related to measurement. | Solves problems related to measurement with assistance. |

# *Elementary Level — Sample Rubrics for Process Skills*

## Observing

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Uses Senses | Uses all five senses interchangeably to gain information about objects or events; descriptively communicates information about all attributes/properties. | Uses all five senses to gain information about objects or events; communicates information gained about some, but not all attributes/properties. | Uses some of the five senses to gain information about objects or events; needs assistance communicating information gained. |
| Applies Information | Identifies and compares attributes/properties of object or event in order to solve problems and extends this knowledge to other situations. | Identifies and compares attributes/properties of object or event in order to solve problems. | Identifies attributes/properties of object or event but needs assistance using this information to solve problems. |

## Patterning

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Recognition | Recognizes complex patterns. (AABAAB - AABAAB...) | Recognizes simple patterns. (AB - AB - AB...) | Does not recognize patterns. |
| Continue/Reproduce | Proposes and explores extensions. | Makes connections and recognizes similar applications. | Does not make connections to continue pattern. |
| Communication | Communicates patterns clearly and effectively. | Can support simple explanations of patterning. | Cannot explain patterns. |

# *Elementary Level — Sample Rubrics for Process Skills*

## Predicting

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Uses Prior Knowledge | Applies relevant prior knowledge to new situations. | Prompting or assistance needed to apply relevant prior knowledge to new situations. | Unable to apply relevant prior knowledge to new situations. |
| Forecasting | Uses inferences to make a specific prediction of what a future observation will be. | Prompting or assistance needed to use inferences to make a specific prediction of what a future observation will be. | Unable to use inferences to make a specific prediction of what a future observation will be. |

## Problem Solving

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Clarifies the problem | Can restate or explain the problem coherently. | Misinterprets or misunderstands part of the problem. | Does not attempt the problem or misunderstands the problem. |
| Formulates and Applies Strategies, Concepts, and Procedures. | Knows and uses many strategies; generates new procedures. | Knows and uses a limited number of strategies; can complete work in an acceptable manner. | Makes no attempt to do the problem; cannot explain work or strategy adequately. |
| Collects, Organizes, and Displays Data. | Can collect and display data in an organized manner. | Has minor flaws in collecting or displaying data. | Makes no attempt or makes major mistakes in collecting or displaying data. |
| Summarizes and interprets results. | Draws valid conclusions/ interpretations; makes sound generalizations. | Summarizes and describes data appropriately; can generate/answer questions related to data. | Makes no attempt to summarize or describe data. |
| Communicates Results | Communicates clearly and effectively; explains thinking process well; can communicate ideas in several forms. | Expresses ideas in simple form; can support simple explanations; uses some terms appropriately. | Has difficulty communicating ideas; cannot bring thinking to conscious level; does not use or misuses terms; offers unrelated information. |

# *Elementary Level — Sample Rubrics for Process Skills*

## Hypothesizing — Upper Level

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Research | Independently demonstrates research skills using a variety of resources. | Demonstrates research skills with teacher/peer assistance. | Unable to demonstrate research skills. |
| Observation | Independently demonstrates observation skills. | Demonstrates observation skills with teacher/peer assistance. | Unable to demonstrate observation skills. |
| Questioning | Independently able to formulate pertinent questions reflecting higher-level thinking skills. | Able to formulate pertinent questions with teacher/peer assistance. | Unable to formulate questions. |
| Inferences | Independently able to use content clues in making an inference. | Makes inferences with teacher/peer assistance. | Unable to demonstrate inference skills. |
| Generalized Statements | Able to form a generalized statement based on research, observation, questions, and inference skills. | Able to form a generalized statement with teacher/peer assistance. | Unable to form a generalized statement. |

## Inferences — Upper Level

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Interpreting | Clearly and accurately selects and describes important information to make general conclusions or statements. | Accurately selects and describes important information to make general conclusions or statements with teacher/peer assistance. | Unable to select and describe important information to make general conclusions or statements. |
| Explaining | Independently explains interesting ideas or meanings from information. | Explains interesting ideas or meanings from information with teacher/peer assistance. | Unable to explain ideas or meanings from information. |
| General Conclusions | Independently formulates general conclusions from specific pieces of information or observations. | Formulates general conclusions from specific pieces of information or observations with teacher/peer assistance. | Unable to formulate general conclusions from specific pieces of information or observation. |

# *Elementary Level — Sample Rubrics for Process Skills*

## Questioning — Upper Level

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Inquiring | Independently formulates logical questions based on facts, concepts, or principles. | Formulates logical questions based on facts, concepts, or principles with teacher/peer assistance. | Unable to formulate questions based on facts, concepts, or principles. |
| Searching | Formulates questions that consistently interprets and synthesizes information gathered. | Formulates questions that interprets and synthesizes information gathered with teacher/peer assistance. | Unable to formulate questions through interpreting and synthesizing information gathered. |
| Pertinent Information | Formulates questions paying close attention to detail when appropriate; checks information against all important sources and recognizes inaccuracies. | Formulates questions paying adequate attention to detail when appropriate; checks information against all important sources, and recognizes inaccuracies with teacher/peer assistance. | Unable to formulate questions using details; unable to check information against all important sources and to recognize inaccuracies. |

# *Middle/Secondary Level — Sample Rubrics for Process Skills*

## Classifying

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Determine Attributes of Groups | Is able to place in a hierarchy of groups. | Is able to place in groups but in a random manner. | Unable to place all items in groups. |
| Label Groups | Is able to label groups appropriately. | Is able to label groups appropriately most of the time. | Is not able to label groups appropriately. |
| Pattern Recognition | Notices patterns among objects and is able to extend pattern. | Notices patterns among objects but is unable to extend. | Unable to determine patterns. |

## Communicating

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Expressing Ideas | Able to express abstract and concrete ideas clearly and concisely. | Able to express ideas which can be clarified with few questions. | Unable to express meaning of ideas to others. |
| Organization | Presents ideas in sequential order. | Presents most ideas in a sequential manner. | Ideas are often out of sequence. |
| Accuracy | Ideas and concepts contain no serious flaws. | Ideas and concepts contain few minor flaws. | Ideas and concepts contain few serious flaws. |
| Models of Communication | Uses several modes to communicate ideas. | Uses two modes of communication. | One mode of communication used. |
| Reasoning | Explains thinking processes well. | Able to support simple explanations. | Unable to verbalize thinking. |
| Questioning | Responds to all questions and initiates questions. | Has difficulty responding to or asking questions. | Does not respond or ask questions. |

# *Middle/Secondary Level — Sample Rubrics for Process Skills*

## Connecting

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Technology | Uses appropriate/available technology effectively and correctly. | Uses some technology in an acceptable way. | Available technology not used. |
| Integration Across Disciplines | Able to apply ideas to other disciplines. | Able to sometimes apply ideas to other disciplines. | Able to use ideas in a single discipline. |
| Integration Within Disciplines | Proposes and explores extensions within disciplines. | Able to recognize similar problems or applications within disciplines. | Does not attempt to make connections within disciplines. |
| Connecting to "Real" Life | Explores "real" life situations connecting many disciplines. | Explores "real" life situations connecting some disciplines. | Attempts but is unable to explore "real" life situations connecting other disciplines. |
| Relationship | Relates objects, data, and procedures in one situation with real-life situations. | Misses critical relationships between real-life situations. | Identifies similar objects, data, or procedures but unable to connect to real-life situations. |

## Hypothesizing

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Explains Inferences | Explains all inferences. | Explains some inferences. | Does not explain inferences. |
| Explains Observations | Writes a statement based on many observable sources of information. | Writes a statement based on some observable sources of information. | Writes a statement not based on observable sources of information. |
| Generalized Statement | Is able to write a generalized statement as a null hypothesis. | Is able to write a generalized statement. | Is unable to write a generalized statement. |

## Inferring

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Make Inferences | Able to accurately infer properties or occurrences about observations and/or data. | Able to sometimes make an inference about properties of data and observations. | Unable to accurately infer properties about observations and/or occurrences about data. |

# *Middle/Secondary Level — Sample Rubrics for Process Skills*

## Interpreting Data

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Draw Conclusions | Able to state a clear and accurate conclusion from data. | Able to state a clear and accurate conclusion most of the time. | Unable to make a clear conclusion. |
| Read Data | Able to make interpretation of data and is aware of exceptions. | Able to make interpretations but is not aware of exceptions. | Unable to make interpretations and is unaware of exceptions. |

## Measuring

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Measurement Tools | Can determine appropriate tool to use for measurement. | Can determine the appropriate tool to use most of the time. | Cannot determine the appropriate tool. |
| Read Measurements | Can accurately read measurement tool by increments to its significant digit. | Can accurately read measurement tool. | Cannot accurately read measurement tool. |
| Unit of Measure | Can determine appropriate unit of measurement to use. | Can determine the appropriate unit of measurement most of the time. | Cannot determine the appropriate unit of measurement. |
| Standard vs. Nonstandard | Can measure and/or estimate between standard and nonstandard units. | Uses limited estimation between standard and non-standard units. | Unable to estimate between standard and non-standard units. |

## Modeling

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Constructing a Model | Able to construct a model illustrating the concept and explain the relationship. | Able to use a model illustrating the concept and explain the relationship. | Unable to use a model or explain the relationship. |

# *Middle/Secondary Level — Sample Rubrics for Process Skills*

## Observing

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Observing | Methodically and thoroughly records observations. | Records observations. | Randomly records observations. |
| Using Five Senses | Uses all five senses as appropriate. | Uses most of the senses as appropriate. | Uses one sense to gather information. |

## Patterning

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Locating Patterns | Able to locate a repetitive pattern in many events or problems. | Able to locate repetitive patterns in most events. | Has difficulty locating patterns. |
| Expressing Patterns | Expresses patterns using variables. | Expresses patterns using examples. | Unable to express patterns. |
| Extending Patterns | Extends pattern to many other problems. | Extends pattern to some other problems. | Has difficulty using patterns in other problems. |
| Applications | Able to create parallel problems by varying conditions of original problems. Can apply ideas to new situations. | Able to create parallel problems. Unable to apply ideas to new situations. | Unable to apply to parallel problems. |

# *Middle/Secondary Level — Sample Rubrics for Process Skills*

## Problem Solving

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| States Problem | States the problem in her/his own words. Identifies questions that must be answered. Eliminates unnecessary information. | Recognizes the problem. Identifies some questions to be answered. | Cannot recognize the problem. |
| Hypothesize/ Estimate | Can hypothesize/estimate answer. | Hypothesis/estimate sometimes inconsistent with the problem. | Hypothesis/estimate frequently inconsistent with the problem. |
| Develop Strategy for Solution | Can develop a clear strategy for solving the problem. | Uses trial and error to develop a strategy. | Cannot develop a problem-solving strategy. |
| Information | Identifies needed information and shows evidence of research. | Misinterprets or misunderstands related information. | Routinely requires explanation and assistance. |
| Generalization and Flexibility Estimate | Successfully resolves unexpected difficulties that arise during the process. Is able to generalize findings to other solutions. | Tries to resolve unexpected difficulties that arise during the process. Needs assistance to generalize findings to other solutions. | Refuses assistance. Does not recognize the need for assistance. |
| Evaluate Answer | Is able to evaluate solution for reasonableness and will redo until reasonable. | Can ascertain reasonableness but cannot redo using a different strategy. | Cannot evaluate or ascertain reasonableness of answer. |
| Understanding | Uses correctly all process skills as needed. Can restate and explain the problem. | Correctly uses some process skills needed but misses opportunity to use a process skill important to the task. | Uses process skills incorrectly. Misunderstands the problem. |

## Predicting

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Explaining Predictions | Able to explain how the prediction was made based on prior knowledge, experience, and/or content clues. Refines prediction to suggest a more accurate solution. | Able to explain prediction based on prior knowledge, experience, and/or content clues. | Unable to explain reasons for predictions beyond intuition. Makes unrealistic predictions. |

# *Middle/Secondary Level — Sample Rubrics for Process Skills*

## Questioning

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Pertinent Information | Generates questions related to topic and identifies pertinent information. | Generates questions related to the topic. | Unable to generate questions related to the topic. |
| Research on Question/Topic | States the question based on researched information, current knowledge, and observations. | States the question based on observations. | Question is not based on any background observations or knowledge. |
| Investigative Question | Proposes questions suitable for experimental design or research. | Proposes questions narrowed enough for experimentation. | Proposes questions too broad for experimentation. |

## Researching

| Criteria | Proficient | Basic | In Progress |
|---|---|---|---|
| Access Information | Gathers necessary information using a variety of methods and sources. | Gathers some information using a limited number of methods and sources. | Unable to gather information without assistance. |
| Interpret Information | Organizes information into a useful form. | Organizes data incompletely. | Cannot organize or interpret data. |
| Control Variables | Recognizes the value and is successful in controlling variables. | Recognizes the value but does not control variables successfully. | Does not recognize the value of controlling the variables. |
| Determine Possible Relationships | Correctly identifies relationships, recognizes connections, and synthesizes major ideas. | Able to identify most relationships but has difficulty connecting all ideas. | Does not correctly identify relationships. Can not connect ideas. |