Unit Overview

SkyMath is designed to support mathematics education in accordance with new standards set by the National Council of Teachers of Mathematics. It is a flexible curriculum that can be taught as a single unit over the course of six to eight weeks or in smaller sections throughout the school year. It builds on the experience, interests, skills, and knowledge that students already have and develops these through hands-on activities, real data, and students' own questions and projects.

SkyMath activities use a developmental approach. Through a combination of structured experiences and open-ended explorations, student understanding moves from particular examples to general cases, from small data sets to large ones, from off-line activities to on-line investigations, and from concrete images to abstract ideas. SkyMath students learn mathematical concepts as they collect and analyze real-time weather data using different kinds of thermometers, computers, data loggers, and the Internet, as well as newspapers, TV, and radio. These experiences, which culminate in student-initiated final projects, go beyond basic skills to elicit higher-level thinking, reflection, and the communication of mathematical ideas.

Some of the problems that students encounter while doing SkyMath are explicitly written into the curriculum, typically as exercises or assessments. These problems may have a single correct answer or they may have more than one solution (and often, no single *best* solution). Other problems will arise naturally during the unit. For example, one of your thermometers may be a few degrees off, compared with the others in your classroom. Should students make a numerical adjustment to the readings they take with this thermometer? Should they simply discard it? Either solution is workable. More examples of these kinds of problems can be found in the Teachers' Stories throughout the unit. Although not all problems can be anticipated, each new problem is a problem-solving opportunity for students. Your role, as a SkyMath teacher, is not only to help students learn new concepts and acquire or develop new skills but also to help them identify and define new problems, propose solutions, and try out their solution strategies to see what works best. In these ways, students will learn that mathematics is not a cut-and-dried series of rules and skill sets, but a tool that, when used thoughtfully and creatively, allows them to solve real-world problems as well as textbook ones.

Special Features

Other features of SkyMath that distinguish it as a mathematics curriculum are highlighted and discussed in the following pages. These features include student groupwork, mathematical communication, student-posed questions, e-mail, and alternative pathways for implementation of the curriculum.

SKYMATH STUDENTS WORK IN GROUPS

The ability to work in a team is an increasingly valued skill in our society. Today's students must prepare for joining a workforce in which complex tasks can be accomplished only through team effort. Individual achievement will continue to be important, but perhaps now more than ever before, individuals must also learn to cooperate with others and contribute fully to a group to ensure their own success.

Groupwork in mathematics class can be highly motivating for students, provided that the groundrules are understood and accepted. Many excellent books offer details about how to manage groupwork in the classroom. The resource list at the end of this overview suggests a few. However, the SkyMath curriculum does not require you to adopt any particular style of groupwork or follow any special format. Simply allowing students to move their desks together is one of the easiest and most effective ways to facilitate their groupwork. You may also want each group to decide on a team name and perhaps do one or two group-building activities before starting this unit. Another point to remember in managing student groupwork is to make sure that each member of the group is productively engaged, respectful of other members of the group, and fully accountable for the work produced by the group as a whole.

The first section of the SkyMath curriculum introduces groupwork through a brainstorming and presentation activity. As the unit progresses, students collaborate to prepare e-mail messages, explore Blue Skies and other sources of weather data on the Internet, find patterns in spreadsheet data, consider ways to find an average, display and interpret data in tables and graphs, and make decisions based on an analysis of data. As students begin to decide on a final project, those with similar interests may want to work together to develop a research question and carry out their investigation.

SKYMATH STUDENTS COMMUNICATE THEIR IDEAS

Integrating the four language arts (speaking, listening, reading, and writing) into the mathematics curriculum helps students "compare experiences, clarify their thinking, and develop an understanding of how the mathematics they study in school is related to the mathematics they experience in the 'real world'" (National Council of Teachers of Mathematics, 1994, page v). An important benefit for students that comes from working with a partner or in a small group is that doing so encourages them to articulate their ideas. Students are capable of accomplishing a great deal when they can talk to their peers. One person's ideas will trigger another's, and solutions to problems can often emerge in this way. Thus, two or more students working together are likely to deepen their understanding to a greater extent than if they were working strictly on their own.

Many opportunities have been built into this SkyMath curriculum for students to communicate with each other as they work together in small groups or take part in whole-class discussions or presentations. For example, each of the 15 activities begins with a question that you can pose as a way to introduce the activity. As students begin to consider these questions, they should be invited to express their beliefs, opinions, prior experiences, and expectations. That will give them a greater stake in carrying out the mathematical activities that will lead to answers. Other occasions for students to exchange ideas will occur as they work with a partner or in a small group, deciding how to construct a graph, calculate an average, read a scale, or spot a pattern in temperature data. The final projects will require students to communicate their research question, their method for answering their question, and their results.

Students will communicate their ideas by talking, in writing, and with tables, graphs, and other representations of data. In whole-class discussions and in small group sessions or individual interviews, encourage students to explain what they are doing and to share what they have learned with other members of the class. Invite students to describe a problem they have encountered, and challenge others to propose ways to solve the problem. Or ask students to detail the steps they followed to solve a problem, and compare the strategies used by different students.

SkyMath Students Ask Questions

Do good questions capture students' attention? In what ways do students benefit from learning to formulate good questions? How can students develop question-posing skills? Good questions prompt those who encounter them to start to think about what the answers might be. Posing questions is an important skill for students to develop, but one that has received little attention in the classroom. When students pose questions, they begin to take a more active role in their learning. Their questions reveal what they don't yet know or understand, as well as what puzzles them or sparks their interest.

Early in this SkyMath unit, students produce a set of questions about temperature and the weather. Post their questions on a bulletin board to remind students during the unit of what they have learned and what they don't yet know. New questions can be added to the list as they arise, and the list can help students think about what question they want to answer in their final project.

Encourage students to participate in class discussions by asking questions of each other. For example, when a group of students is making a presentation, invite the rest of the class members to question anything that isn't clear to them or to inquire about some aspect of the presentation about which they want to know more. These kinds of questions will help to create a learning community in your classroom, one where students support, challenge, and learn from each other.

Don't be surprised if students have trouble thinking of questions at first. As they begin to do the work of the unit, more and more questions will occur to them. Some questions that seem silly may in fact reflect a genuine interest or a confusion, so try to accept all questions uncritically rather than discourage students by rejecting or discounting them. Sometimes, asking students to explain what they mean will reveal the sense behind an apparently nonsensical question.

Don't worry if some questions seem unanswerable. Use them to challenge students to shape other, smaller questions that, if answered, could help to answer the bigger question. Let your goal be to help students recognize that it is the pursuit of answers to interesting questions that leads to new discoveries and intellectual growth.

SKYMATH STUDENTS EXCHANGE E-MAIL

Students are almost universally enthusiastic about exchanging e-mail with other students. They look forward to writing and posting messages, and eagerly await responses. This SkyMath unit has five structured activities in which students send e-mail to a partner class to introduce themselves, compare personal scales, and share StowAway™ data and weather observations.

Students will be preparing their messages as part of their groupwork. Your students' writing and keyboarding skills and the accessibility of computers in your school will have some bearing on how you manage this process. Writing and sending e-mail can take up a fair amount of time, so you will need to do some strategic planning to ensure that this aspect of the unit goes smoothly. You may want to enlist the help of a language arts teacher to review the messages students write, or ask the computer teacher to supervise students as they key in their messages. Since your class as well as your partner class will be eager to get a reply to any message students send, you should also stay in close touch with your partner teacher so that you both can let students know when to expect the next batch of messages. Keep in mind that a nonresponse or even a slow response can be quite frustrating for students.

The SkyMath Mailing List is an electronic message exchange where teachers can write to each other and see what other teachers have written. Any message sent to this list will be distributed to the e-mail boxes of each of the members of the list. If you need to find a partner class with whom to exchange e-mail, send a message to the list introducing yourself and explaining that you are looking for another class that will be starting SkyMath at the same time as your class. You may need to send more than one message before you find a partner, so be persistent!

To subscribe to the SkyMath Mailing List, send a message via Internet to the following:

Majordomo@unidata.ucar.edu

Leave the subject line blank. In the body of your message, write:

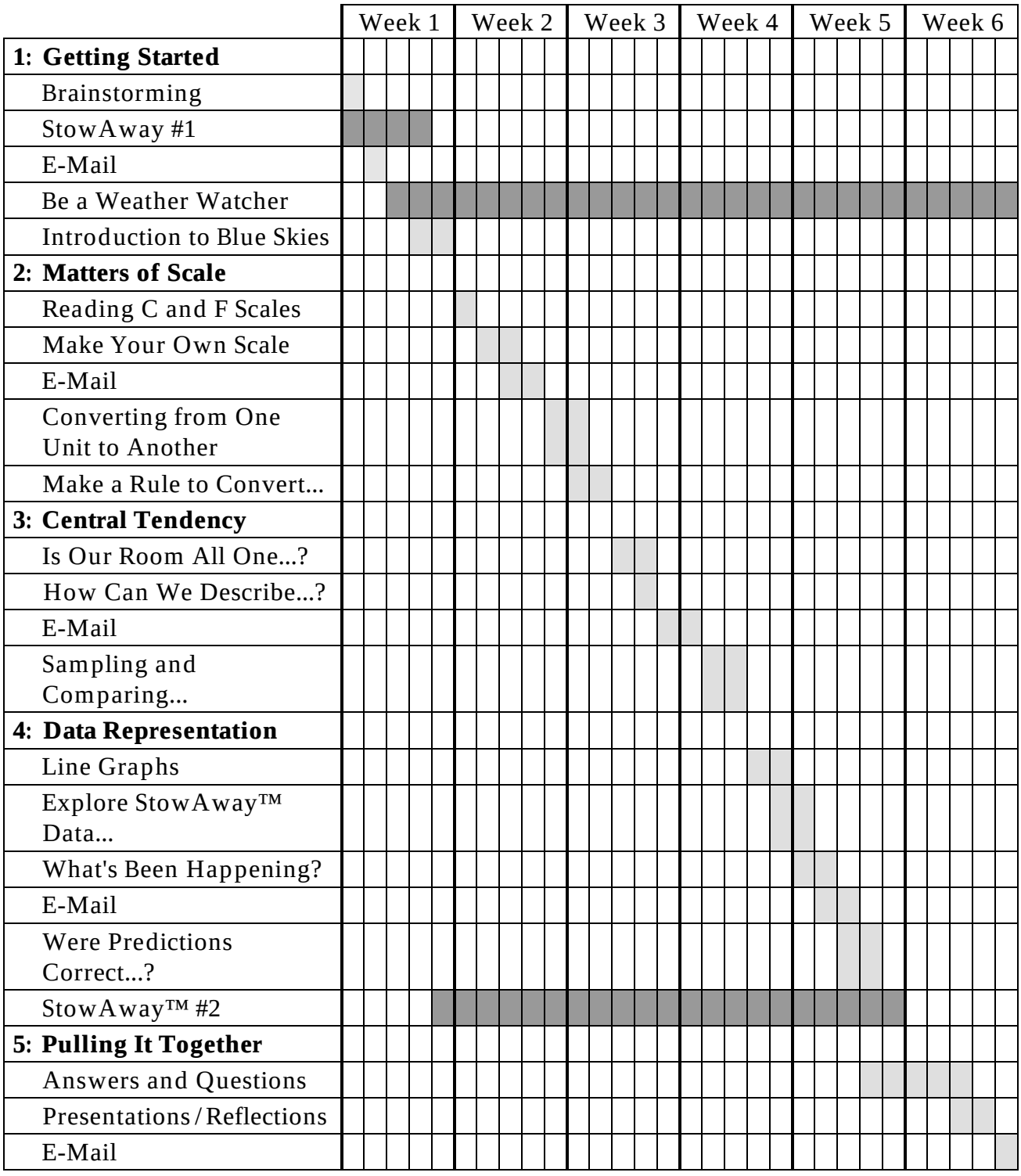
subscribe SkyMath first-name last-name

Substitute your own first and last name after the word SkyMath. The list server will then send you instructions about how to post messages.

SKYMATH CLASSROOMS CHOOSE THEIR OWN PATHS

Your path through this SkyMath unit depends to a large degree on your own situation and your students' interests. As a rule, the numbered activities are intended to be presented in succession, but some activities (or parts of activities) can be skipped if they don't make sense in your classroom. Within each activity, Teachers' Stories illustrate variations and spinoffs that you may want to use with your students.

The following calendar shows how the entire unit might be implemented over a six-week period. It is only a rough guide to help you in your planning, not a schedule to be followed precisely.



Note: Weather Watcher and StowAway™ #1 and #2 are extended data collection activities.

To do SkyMath in its entirety, you will need the following materials and equipment:

- at least one computer with Internet access and BlueSkies installed (BlueSkies can be downloaded from the University of Michigan Weather Underground gopher, **insert instructions**)
- an e-mail account
- at least one StowAway™ temperature data logger with a six-foot probe and Logbook® software
- spreadsheet software
- at least 12 indoor thermometers
- at least one min-max thermometer
- an overhead projector and the ability to make transparencies

If you have no StowAway™ data loggers, limited or no access to computers, or no connection to the Internet, you will need to do a scaled-down version of SkyMath. The following paragraphs detail the activities to drop if these conditions apply to you.

If you have no StowAway™ data logger, you will need to omit Activity 12 (Exploring the StowAway™ Data) and Activity 13 (What's Been Happening?).

If you have no computer, you can still do most of SkyMath by omitting activities involving the StowAway™ data logger, e-mail, Blue Skies, and other Internet sites. This means you must omit Activity 3 (Introduction to Blue Skies) and all of Section 4, Data Representation and Change, with the exception of Activity 11 (Line Graphs).

If you have at least one computer but no telecommunications functionality, omit Activity 3 (Introduction to Blue Skies), Activity 14 (Were the Predictions Correct?), and the e-mail activities.

SkyMath Math Goals

Each activity in the SkyMath module addresses specific mathematics learning goals. The following is a list of all the SkyMath mathematics goals by activity.

ACTIVITY 1

- Students identify questions and pose problems that can be solved using mathematics.
- Students are introduced to the Celsius and Fahrenheit temperature scales.

ACTIVITY 2

- Students review what state, national, and world weather data are available and how those data are collected.
- Students design a process for collecting data to answer local weather-related questions.
- Students decide on a common set of data to be collected.
- Students learn how to read a thermometer in Fahrenheit and Celsius scales.
- Students learn how to use a weather log, read and record temperatures, and calculate changes.

ACTIVITY 3

- Students read a min-max thermometer.
- Students record minimum and maximum temperatures and analyze differences.
- Students use maps to identify locations.
- Students look for patterns of differences across the United States.
- Students learn to use Blue Skies to access and upload temperature and weather data.

ACTIVITY 4

- Students learn to read Celsius and Fahrenheit thermometers with intervals representing 1 and 2 degrees, respectively.
- Students match Fahrenheit and Celsius temperatures.
- Students explore signed numbers as a way to represent temperatures above and below zero.
- Students add and subtract signed numbers (integers).
- Students look for patterns and discuss rules.

ACTIVITY 5

- Students list statements that are measured by temperature, and rank order them.
- Students review how Fahrenheit and Celsius created their temperature scales.
- Students make and calibrate their own temperature scales by identifying fixed reference points.
- Students find differences and use other operations.
- Students measure distances and divide them into equal intervals.
- Students assign temperatures to events.

ACTIVITY 6

- Students describe how units of measurement are mathematically related.
- Students develop formulas for converting between units of measurement.

ACTIVITY 7

- Students identify and describe mathematically significant patterns in data sets.
- Students use ratios to describe the relationship between two scales.
- Students graph number pairs on a coordinate system.
- Students discuss properties of their graph, such as slope and intercepts.
- Students use the slope of the line to informally develop and describe a rule for converting between Fahrenheit and Celsius scales.
- Students translate an informal rule into a formula using a spreadsheet.
- Students create spreadsheets for converting between Celsius and Fahrenheit and describe the rule.

ACTIVITY 8

- Students read analog thermometers.
- Students examine the concept of calibration (equating scales so that all instruments read the same at the same location and the same time).
- Students make conjectures about room temperature.
- Students make bar graphs.
- Students consider maximum, minimum, and range of temperature readings in the room.

ACTIVITY 9

- Students examine the concept of “typical,” or average, and explain their reasoning.
- Students are introduced to measures of central tendency: mode, median, and mean.
- Students discuss which measure of central tendency best describes the typical temperature in the room and in a given situation.
- Students explore the effects of extreme data points on the mode, median, and mean of a data set.

ACTIVITY 10

- Students discuss ways to gather data to determine the “average temperature” at a location.
- Students report on and critique their plans.
- Students are encouraged to consider how the choice of measure of central tendency is affected by sample size, placement of recording devices, timing, range, and repetition of specific readings.
- Students identify extremes, compute the range, and find the mean, median, and mode of given sets of data.
- Students make decisions based on an analysis of data.

ACTIVITY 11

- Students read and interpret line graphs; they discuss scales, axes, and labels.
- Students construct line graphs to show changes in temperature over time.
- Students use line graphs to informally compare rates of change.
- Students use line graphs to informally discuss slope.

ACTIVITY 12

- Students interpret line graphs and discuss patterns in the data.
- Students use the LogBook® software to construct a line graph and import data into a spreadsheet.
- Students use the data from the StowAway™ to create a table of temperature highs, lows, and range.
- Students identify patterns and trends in line graphs and tables.
- Students compare weather log data with StowAway™ data.

ACTIVITY 13

- Students calculate the rate of change between high and low temperatures.
- Students explore the meaning of a positive (or negative) rate of change.
- Students relate rate of change to the slope of a line in a line graph.
- Students compare rates of change.
- Students write about data collected outside the classroom using the StowAway ™, noting patterns in the data.

ACTIVITY 14

- Students read and interpret a temperature map and discuss legends, labels, patterns, and differences between predicted and actual high temperatures.
- Students use computers to gather data about high temperatures in selected cities and compare the actual high temperatures with the predicted highs.
- Students represent national highs as color bands on a map.

- Students construct a temperature map of the United States and compare actual to predicted highs for the day.
- Students discuss reasons for differences between predicted and actual temperatures.

ACTIVITY 15

- Students consolidate knowledge and skills acquired in previous sections.
- Students pose and solve authentic problems.
- Students apply reasoning and problem-solving skills to independent projects.

ACTIVITY 16

- Students use mathematical communication to explain the results of their work on a final project.
- Students explain how they solved problems.
- Students reflect on what they have learned.
- Students assess their own progress and achievements.

SkyMath and the NCTM Standards

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Standard 1: Mathematics as Problem Solving																
In grades 5-8, the mathematics curriculum should include numerous and varied experiences with problem solving as a method of inquiry and application so that students can--																
• use problem-solving approaches to investigate and understand mathematical content;	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
• formulate problems from situations within and outside mathematics;	✓														✓	✓
• develop and apply a variety of strategies to solve problems, with emphasis on multistep and nonroutine problems;															✓	✓
• verify and interpret results with respect to the original problem situation;							✓	✓								
• generalize solutions and strategies to new problem situations;							✓								✓	✓
• acquire confidence in using mathematics meaningfully.							✓	✓							✓	✓
Standard 2: Mathematics as Communication																
In grades 5-8, the study of mathematics should include opportunities to communicate so that students can--																
• model situations using oral, written, concrete, pictorial, graphical, and algebraic methods;					✓	✓					✓	✓		✓		
• reflect on and clarify their own thinking about mathematical ideas and situations;					✓											✓
• develop common understandings of mathematical ideas, including the role of definitions;					✓											
• use the skills of reading, listening, and viewing to interpret and evaluate mathematical ideas;																
• discuss mathematical ideas and make conjectures and convincing arguments;	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
• appreciate the value of mathematical notation and its role in the development of mathematical ideas.			✓													

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Standard 3: Mathematics as Reasoning																
In grades 5-8, reasoning shall permeate the mathematics curriculum so that students can--																
• recognize and apply deductive and inductive reasoning;														✓	✓	✓
• understand and apply reasoning processes, with special attention to spatial reasoning and reasoning with proportions and graphs;					✓		✓				✓	✓				
• make and evaluate mathematical conjectures and arguments;							✓								✓	✓
• validate their own thinking;	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
• appreciate the pervasive use and power of reasoning as a part of mathematics.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Standard 4: Mathematical Connections																
In grades 5-8, the mathematics curriculum should include the investigation of mathematical connections so that students can--																
• see mathematics as an integrated whole;																
• explore problems and describe results using graphical, numerical, physical, algebraic, and verbal mathematical models or representations;					✓			✓							✓	✓
• use a mathematical idea to further their understanding of other mathematical ideas;	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
• apply mathematical thinking and modeling to solve problems that arise in other disciplines, such as art, music, psychology, science, and business;																
• value the role of mathematics in our culture and society.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Standard 5: Number and Number Relationships																
In grades 5-8, the mathematics curriculum should include the continued development of number and number relationships so that students can--																
• understand, represent, and use numbers in a variety of equivalent forms (integer, fraction, decimal, percent, exponential, and scientific notation) in real-world and mathematical problem situations;																
• develop number sense for whole numbers, fractions, decimals, integers, and rational numbers;				✓												
• understand and apply ratios, proportions, and percents in a wide variety of situations;						✓	✓									
• investigate relationships among fractions, decimals, and percents;																
• represent numerical relationships in one- and two-dimensional graphs.						✓					✓	✓				
Standard 6: Number Systems and Number Theory																
In grades 5-8, the mathematics curriculum should include the study of number systems and number theory so that students can--																
• understand and appreciate the need for numbers beyond the whole numbers;				✓												
• develop and use order relations for whole numbers, fractions, decimals, integers, and rational numbers;																
• extend their understanding of whole number operations to fractions, decimals, integers, and rational numbers;				✓												
• understand how the basic arithmetic operations are related to one another;																
• develop and apply number theory concepts (e.g., primes, factors, and multiples) in real-world and mathematical problem situations.																

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Standard 7: Computation and Estimation																
In grades 5-8, the mathematics curriculum should develop the concepts underlying computation and estimation in various contexts so that students can--																
• compute with whole numbers, fractions, decimals, integers, and rational numbers;			✓	✓												
• develop, analyze, and explain procedures for computation and techniques for estimation;			✓													
• develop, analyze, and explain methods for solving proportions;																
• select and use an appropriate method for computing from among mental arithmetic, paper-and-pencil, calculator, and computer methods;			✓													
• use computation, estimation, and proportions to solve problems;																
• use estimation to check the reasonableness of results.																
Standard 8: Patterns and Functions																
In grades 5-8, the mathematics curriculum should include explorations of patterns and functions so that students can--																
• describe, extend, analyze, and create a wide variety of patterns;						✓								✓		
• describe and represent relationships with tables, graphs, and rules;				✓	✓						✓	✓				
• analyze functional relationships to explain how a change in one quantity results in a change in another;						✓	✓				✓	✓				
• use patterns and functions to represent and solve problems.						✓	✓				✓	✓				

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Standard 9: Algebra																
In grades 5-8, the mathematics curriculum should include explorations of algebraic concepts and processes so that students can-																
• understand the concepts of variable, expression, and equation;							✓									
• represent situations and number patterns with tables, graphs, verbal rules, and equations and explore the interrelationships of these representations;							✓				✓	✓	✓	✓		
• analyze tables and graphs to identify properties and relationships;				✓			✓				✓	✓	✓			
• develop confidence in solving linear equations using concrete, informal, and formal methods;							✓									
• investigate inequalities and nonlinear equations informally;																
• apply algebraic methods to solve a variety of real-world and mathematical problems.						✓	✓									
Standard 10: Statistics																
In grades 5-8, the mathematics curriculum should include exploration of statistics in real-world situations so that students can--																
• systematically collect, organize, and describe data;		✓						✓							✓	✓
• construct, read, and interpret tables, charts, and graphs;		✓		✓			✓	✓			✓	✓	✓	✓	✓	✓
• make inferences and convincing arguments that are based on data analysis;			✓					✓	✓	✓	✓	✓	✓	✓	✓	✓
• evaluate arguments that are based on data analysis;								✓	✓	✓	✓	✓	✓	✓		
• develop an appreciation for statistical methods as powerful means for decision making.									✓	✓					✓	✓

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Standard 11: Probability																
In grades 5-8, the mathematics curriculum should include explorations of probability in real-world situations so that students can--																
• model situations by devising and carrying out experiments or simulations to determine probabilities;																
• model situations by constructing a sample space to determine probabilities;																
• appreciate the power of using a probability model by comparing experimental results with mathematical expectations;																
• make predictions that are based on experimental or theoretical probabilities;																
• develop an appreciation for the pervasive use of probability in the real world.																
Standard 12: Geometry																
In grades 5-8, the mathematics curriculum should include the study of the geometry of one, two, and three dimensions in a variety of situations so that students can--																
• identify, describe, compare, and classify geometric figures;																
• visualize and represent geometric figures with special attention to developing spatial sense;																
• explore transformations of geometric figures;																
• represent and solve problems using geometric models;																
• understand and apply geometric properties and relationships;																
• develop an appreciation of geometry as a means of describing the physical world.																

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Standard 13: Measurement																
In grades 5-8, the mathematics curriculum should include extensive concrete experiences using measurement so that students can--																
• extend their understanding of the process of measurement;	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
• estimate, make, and use measurements to describe and compare phenomena;		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓			
• select appropriate units and tools to measure to the degree of accuracy required in a particular situation;	✓						✓								✓	✓
• understand the structure and use of systems of measurement;		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
• extend their understanding of the concepts of perimeter, area, volume, angle measure, capacity, and weight and mass;																
• develop the concepts of rates and other derived and indirect measurements;							✓				✓	✓	✓	✓		
• develop formulas and procedures for determining measures to solve problems.				✓		✓	✓									

Resources

BOOKS

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Zawojewski, Judith. *Dealing with data and chance.* Reston, VA: National Council of Teachers of Mathematics. 1991.

Supplies

For **StowAway data loggers**, contact Onset Computer Corporation, PO Box 3450, Pocasset, MA 02559-3450. Telephone: 508-563-9000. E-mail: sales@onsetcomp.com. Internet: HTTP://WWW.onsetcomp.com.

One good source for thermometers is the Nasco Science Catalog. Call 1-800-558-9595 for a copy.

Internet Resources

A thorough discussion of **science concepts** related to temperature, thermometers, and temperature scales can be found at this World Wide Web Site:

About Temperature http://www.unidata.ucar.edu/staff/blynds/tmp.html

Some Web sites allow you to submit questions for experts to answer. Try finding a scientist to query at one of the following sites:

NJ NIE Project Ask an Expert http://njnie.dl.stevens-tech.edu/curriculum/aska.html

The MAD Scientist Network http://medinfo.wustl.edu/~ysp/MSN/

Or for a more comprehensive list of sites along with a lesson on where and how to query an expert, take a look at this site:

Community Learning Network http://www.etc.bc.ca/coop1/courses/science/ScienceLesson5.html