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ABSTRACT

Inventing a new soft drink that is popular and can be produced at low cost is the challenge of this Unified Sciences and Mathematics for Elementary Schools (USMES) unit. The challenge is general enough to apply to many problem-solving situations in mathematics, science, social science, and language arts at any elementary school level (grades 1-8). The Teacher Resource Book for the unit is divided into five sections. Section I describes the USMES approach to student-initiated investigations of real problems, including a discussion of the nature of USMES "challenges." Section II provides an overview of possible student activities with comments on prerequisite skills, instructional strategies, suggestions when using the unit with primary grades, flow charts illustrating how investigations evolve from students' discussions of the problems, and a hypothetical account of primary-level class activities. Section III provides documented events of actual class activities from grades 2, 5, and 6. Section IV includes lists of "How To" cards and background papers, bibliography of non-USMES materials, and a glossary. Section V consists of charts identifying skills, concepts, processes, and areas of study learned as students become involved with the activities. (JN)

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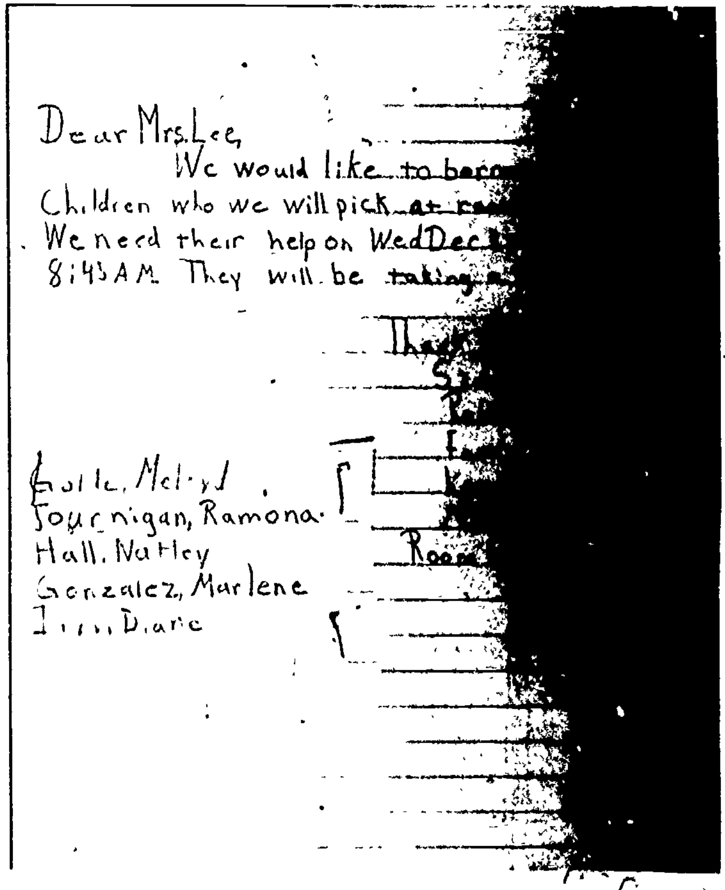
This book is a resource developed by the USMES Project: Earle L. Lomon, Project Director, Betty M. Beck, Associate Director for Development, Thomas L. Brown, Associate Director for Utilization Studies, Quinton E. Baker, Associate Director for Administration.

UNIFIED SCIENCES AND MATHEMATICS FOR ELEMENTARY SCHOOLS:
Mathematics and the Natural, Social, and Communications Sciences in Real Problem Solving.

Soft Drink Design

Fourth Edition



Dear Mrs. Lee,
We would like to
Children who we will pick
We need their help on Wed Dec
8:45 A.M. They will be

Golle, Melvyd
Journigan, Ramona
Hall, Natley
Gonzalez, Marlene
Diane

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Trial Edition

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CHALLENGE: INVENT A NEW SOFT DRINK THAT IS POPULAR AND CAN BE PRODUCED AT A LOW COST.

Table of Contents

cartoon-style booklets for primary grades and a series of magazine-style booklets with more reading matter for upper grades. The *Design Lab "How To" Series* is available in two illustrated card versions--one for primary grades and one for upper grades. A complete list of the *"How To" Series* can be found in the *USMES Guide*.

5. Background Papers: These papers, correlated with the *"How To" Series*, provide teachers with information and hints that do not appear in the student materials. A complete list can be found in the *USMES Guide*.

6. Curriculum Correlation Guide: By correlating the twenty-six USMES units with other curriculum materials, this book helps teachers to integrate USMES with other school activities and lessons.

The preceding materials are described in brief in the USMES brochure, which can be used by teachers and administrators to disseminate information about the program to the local community. A variety of other dissemination and implementation materials are also available for individuals and groups involved in local implementation programs. They include *Preparing People for USMES: An Implementation Resource Book*, the USMES slide/tape show, the Design Lab slide/tape show, the Design Lab brochure, videotapes of classroom activities, a general report on evaluation results, a map showing the locations of schools conducting local implementation of USMES, a list of experienced USMES teachers and university consultants, and newspaper and magazine articles.

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Because Tri-Wall was the only readily available brand of three-layered cardboard at the time the project began, USMES has used it at workshops and in schools; consequently, references to Tri-Wall can be found throughout the Teacher Resource Books. The addresses of suppliers of three-layered cardboard can be found in the Design Lab Manual.

Preface

The USMES Project

Unified Sciences and Mathematics for Elementary Schools: Mathematics and the Natural, Social, and Communications Sciences in Real Problem Solving (USMES) was formed in response to the recommendations of the 1967 Cambridge Conference on the Correlation of Science and Mathematics in the Schools.* Since its inception in 1970, USMES has been funded by the National Science Foundation to develop and carry out field trials of interdisciplinary units centered on long-range investigations of real and practical problems (or "challenges") taken from the local school/community environment. School planners can use these units to design a flexible curriculum for grades kindergarten through eight in which real problem solving plays an important role.

Development and field trials were carried out by teachers and students in the classroom with the assistance of university specialists at workshops and at occasional other meetings. The work was coordinated by a staff at the Education Development Center in Newton, Massachusetts. In addition, the staff at EDC coordinated implementation programs involving schools, districts, and colleges that are carrying out local USMES implementation programs for teachers and schools in their area.

Trial editions of the following units are currently available:

Advertising	Nature Trails
Bicycle Transportation	Orientation
Classroom Design	Pedestrian Crossings
Classroom Management	Play Area Design and Use
Consumer Research	Protecting Property
Describing People	School Rules
Designing for Human Proportions	School Supplies
Design Lab Design	School Zoo
Eating in School	Soft Drink Design
Getting There	Traffic Flow
Growing Plants	Using Free Time
Manufacturing	Ways to Learn/Teach
Mass Communications	Weather Predictions

*See *Goals for the Correlation of Elementary Science and Mathematics*, Houghton Mifflin Co., Boston, 1969.

USMES Resources

In responding to a long-range challenge, the students and teachers often have need of a wide range of resources. In fact, all of the people and materials in the school and community are important resources for USMES activities. In addition USMES provides resources for both teachers and students. A complete set of all the written materials comprise the USMES library, which should be available in each school using USMES units. These materials include--

1. *The USMES Guide*: This book is a compilation of materials that may be used for long-range planning of a curriculum that incorporates the USMES program. It describes the USMES project, real problem solving, classroom strategies, the Design Lab, the units, and the support materials as well as ways that USMES helps students learn basic skills.

2. *Teacher Resource Books* (one for each challenge): Each of these guides to using USMES units describes a broad problem, explains how students might narrow that problem to fit their particular needs, recommends classroom strategies, presents edited logs from teachers whose classes have worked on the unit, and contains charts that indicate basic skills, processes, and areas of study that students may learn and utilize.

3. *Design Lab Manual*: This guide helps teachers and administrators set up, run, and use a Design Lab--a place with tools and materials in which the students can build things they need for their work on USMES. A Design Lab may be a corner of a classroom, a portable cart, or a separate room. Because many "hands-on" activities may take place in the classroom, every USMES teacher should have a Design Lab Manual.

4. *"How To" Series*: These student materials provide information to students about specific problems that may arise during USMES units. The regular *"How To" Series* covers problems in measuring, graphing, data handling, etc., and is available in two versions--a series of

Introduction

Using the Teacher Resource Book

When teachers try a new curriculum for the first time, they need to understand the philosophy behind the curriculum. The USMES approach to student-initiated investigations of real problems is outlined in section A of this Teacher Resource Book.

Section B starts with a brief overview of possible student activities arising from the challenge; comments on prerequisite skills are included. Following that is a discussion of the classroom strategy for USMES real problem-solving activities, including introduction of the challenge, student activity, resources, and Design Lab use. Subsequent pages include a description of the use of the unit in primary grades, a flow chart and a composite log that indicate the range of possible student work, and a list of questions that the teacher may find useful for focusing the students' activities on the challenge.

Because students initiate all the activities in response to the challenge and because the work of one class may differ from that undertaken by other classes, teachers familiar with USMES need to read only sections A and B before introducing the challenge to students.

Section C of this book is the documentation section. These edited teachers' logs show the variety of ways in which students in different classes have worked at finding a solution to the challenge.

Section D contains a list of the titles of relevant sets of "How To" Cards and brief descriptions of the Background Papers pertaining to the unit. Also included in section D is a glossary of the terms used in the Teacher Resource Book and an annotated bibliography.

Section E contains charts that indicate the comparative strengths of the unit in terms of real problem solving, mathematics, science, social science, and language arts. It also contains a list of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in the unit. These charts and lists are based on documentation of activities that have taken place in USMES classes. Knowing ahead of time which basic skills and processes are likely to be utilized, teachers can postpone teaching that part of their regular program until later in the year. At that time students can study them in the usual way if they have not already learned them as part of their USMES activities.

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A. Real Problem Solving and USMES

> *If life were of such a constant nature that there were only a few chores to do and they were done over and over in exactly the same way, the case for knowing how to solve problems would not be so compelling. All one would have to do would be to learn how to do the few jobs at the outset. From then on he could rely on memory and habit. Fortunately--or unfortunately depending upon one's point of view--life is not simple and unchanging. Rather it is changing so rapidly that about all we can predict is that things will be different in the future. In such a world the ability to adjust and to solve one's problems is of paramount importance.**

Real Problem Solving

USMES is based on the beliefs that real problem solving is an important skill to be learned and that many math, science, social science, and language arts skills may be learned more quickly and easily within the context of student investigations of real problems. Real problem solving, as exemplified by USMES, implies a style of education which involves students in investigating and solving real problems. It provides the bridge between the abstractions of the school curriculum and the world of the student. Each USMES unit presents a problem in the form of a challenge that is interesting to children because it is both real and practical. The problem is real in several respects: (1) the problem applies to some aspect of student life in the school or community, (2) a solution is needed and not presently known, at least for the particular case in question, (3) the students must consider the entire situation with all the accompanying variables and complexities, and (4) the problem is such that the work done by the students can lead to some improvement in the situation. This expectation of useful accomplishment provides the motivation for children to carry out the comprehensive investigations needed to find some solution to the challenge.

The level at which the children approach the problems, the investigations that they carry out, and the solutions

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*Kenneth B. Henderson and Robert E. Pingry, "Problem-Solving in Mathematics," in *The Learning of Mathematics: Its Theory and Practice,* Twenty-first Yearbook of the National Council of Teachers of Mathematics (Washington, D.C.: The Council, 1953), p. 233.

that they devise may vary according to the age and ability of the children. However, real problem solving involves them, at some level, in all aspects of the problem-solving process: definition of the problem; determination of the important factors in the problem; observation; measurement; collection of data; analysis of the data using graphs, charts, statistics, or whatever means the students can find; discussion; formulation and trial of suggested solutions; clarification of values; decision making; and communications of findings to others. In addition, students become more inquisitive, more cooperative in working with others, more critical in their thinking, more self-reliant, and more interested in helping to improve social conditions.

The USMES Approach

To learn the process of real problem solving, the students must encounter, formulate, and find some solution to complete and realistic problems. The students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of their hypotheses and conclusions. In real problem-solving activities, the teacher acts as a coordinator and collaborator, not an authoritative answer-giver.

The problem is first reworded by students in specific terms that apply to their school or community, and the various aspects of the problem are discussed by the class. The students then suggest approaches to the problem and set priorities for the investigations they plan to carry out. A typical USMES class consists of several groups working on different aspects of the problem. As the groups report periodically to the class on their progress, new directions are identified and new task forces are formed as needed. Thus, work on an USMES challenge provides students with a "discovery-learning" or "action-oriented" experience.

Real problem solving does not rely solely on the discovery-learning concept. In the real world people have access to certain facts and techniques when they recognize the need for them. The same should be true in the classroom. When the students find that certain facts and skills are necessary for continuing their investigation, they learn willingly and quickly in a more directed way to acquire these facts and skills. Consequently, the students should have available different resources that they may use as they recognize the need for them, but they should still be left with a wide scope to explore their own ideas and methods.

Certain information on specific skills is provided by the sets of USMES "How To" Cards. The students are referred only to the set for which they have clearly identified a need and only when they are unable to proceed on their own. Each "How To" Cards title clearly indicates the skill involved--"How to Use a Stopwatch," "How to Make a Bar Graph Picture of Your Data," etc. (A complete list of the "How To" Cards can be found in Chapter IX of the USMES Guide.)

Another resource provided by USMES is the Design Lab or its classroom equivalent. The Design Lab provides a central location for tools and materials where devices may be constructed and tested without appreciably disrupting other classroom activities. Ideally, it is a separate room with space for all necessary supplies and equipment and work space for the children. However, it may be as small as a corner of the classroom and may contain only a few tools and supplies. Since the benefits of real problem solving can be obtained by the students only if they have a means to follow up their ideas, the availability of a Design Lab can be a very important asset.

Optimally, the operation of the school's Design Lab should be such as to make it available to the students whenever they need it. It should be as free as possible from set scheduling or programming. The students use the Design Lab to try out their own ideas and/or to design, construct, test, and improve many devices initiated by their responses to the USMES challenges. While this optimum operation of the Design Lab may not always be possible due to various limitations, "hands-on" activities may take place in the classroom even though a Design Lab may not be available. (A detailed discussion of the Design Lab can be found in Chapter VI of the USMES Guide, while a complete list of "How To" Cards covering such Design Lab skills as sawing, gluing, nailing, soldering, is contained in Chapter IX.)

Work on all USMES challenges is not only sufficiently complex to require the collaboration of the whole class but also diverse enough to enable each student to contribute according to his/her interest and ability. However, it should be noted that if fewer than ten to twelve students from the class are carrying out the investigation of a unit challenge, the extent of their discovery and learning can be expected to be less than if more members of the class are involved. While it is possible for a class to work on two related units at the same time, in many classes the students progress better with just one.

The amount of time spent each week working on an USMES challenge is crucial to a successful resolution of the problem. Each challenge is designed so that the various investigations will take from thirty to forty-five hours, depending on the age of the children, before some solution to the problem is found and some action is taken on the results of the investigations. Unless sessions are held at least two or three times a week, it is difficult for the children to maintain their interest and momentum and to become involved intensively with the challenge. The length of each session depends upon the age level of the children and the nature of the challenge. For example, children in the primary grades may proceed better by working on the challenge more frequently for shorter periods of time, perhaps fifteen to twenty minutes, while older children may proceed better by working less frequently for much longer periods of time.

Student interest and the overall accomplishments of the class in finding and implementing solutions to the challenge indicate when the class's general participation in unit activities should end. (Premature discontinuance of work on a specific challenge is often due more to waning interest on the part of the teacher than to that of the students.) However, some students may continue work on a voluntary basis on one problem, while the others begin to identify possible approaches to another USMES challenge.

Importance of the Challenge

Although individual (or group) discovery and student initiation of investigations is the process in USMES units, this does not imply the constant encouragement of random activity. Random activity has an important place in children's learning, and opportunities for it should be made available at various times. During USMES activities, however, it is believed that children learn to solve real problems only when their efforts are focused on finding some solution to the real and practical problem presented in the USMES challenge. It has been found that students are motivated to overcome many difficulties and frustrations in their efforts to achieve the goal of effecting some change or at least of providing some useful information to others. Because the children's commitment to finding a solution to the challenge is one of the keys to successful USMES work, it is extremely important that the challenge be introduced so that it is accepted by the class as an important problem to which they are willing to devote a considerable amount of time.

The challenge not only motivates the children by stating the problem but also provides them with a criterion for judging their results. This criterion--if it works, it's right (or if it helps us find an answer to our problem, it's

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a good thing to do)--gives the children's ideas and results a meaning within the context of their goal. Many teachers have found this concept to be a valuable strategy that not only allows the teacher to respond positively to all of the children's ideas but also helps the children themselves to judge the value of their efforts.

Role of the Teacher

With all of the above in mind, it can be said that the teacher's responsibility in the USMES strategy for open classroom activities is as follows:

1. Introduce the challenge in a meaningful way that not only allows the children to relate it to their particular situation but also opens up various avenues of approach.

2. Act as a coordinator and collaborator. Assist, not direct, individuals or groups of students as they investigate different aspects of the problem.

3. Hold USMES sessions at least two or three times a week so that the children have a chance to become involved in the challenge and carry out comprehensive investigations.

4. Provide the tools and supplies necessary for initial hands-on work in the classroom or make arrangements for the children to work in the Design Lab.

5. Be patient in letting the children make their own mistakes and find their own way. Offer assistance or point out sources of help for specific information (such as the "How To" Cards) only when the children become frustrated in their approach to the problem. Conduct skill sessions as necessary.

6. Provide frequent opportunities for group reports and student exchanges of ideas in class discussions. In most cases, students will, by their own critical examination of the procedures they have used, improve or set new directions in their investigations.

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7. If necessary, ask appropriate questions to stimulate the students' thinking so that they will make more extensive and comprehensive investigations or analyses of their data.

8. Make sure that a sufficient number of students (usually ten to twelve) are working on the challenge so that activities do not become fragmented or stall.

Student success in USMES unit activities is indicated by the progress they make in finding some solution to the challenge, not by following a particular line of investigation nor by obtaining specified results. The teacher's role in the USMES strategy is to provide a classroom atmosphere in which all students can, in their own way, search out some solution to the challenge.

USMES in the Total School Program

Today many leading educators feel that real problem solving (under different names) is an important skill to be learned. In this mode of learning particular emphasis is placed on developing skills to deal with real problems rather than the skills needed to obtain "correct" answers to contrived problems. Because of this and because of the interdisciplinary nature of both the problems and the resultant investigations, USMES is ideal for use as an important part of the elementary school program. Much of the time normally spent in the class on the traditional approaches to math, science, social science, and language arts skills can be safely assigned to USMES activities. In fact, as much as one-fourth to one-third of the total school program might be allotted to work on USMES challenges. Teachers who have worked with USMES for several years have each succeeding year successfully assigned to USMES activities the learning of a greater number of traditional skills. In addition, reports have indicated that students retain for a long time the skills and concepts learned and practiced during USMES activities. Therefore, the time normally spent in reinforcing required skills can be greatly reduced if these skills are learned and practiced in the context of real problem solving.

Because real problem-solving activities cannot possibly cover all the skills and concepts in the major subject areas, other curricula as well as other learning modes (such as "lecture method," "individual study topics," or programmed instruction) need to be used in conjunction with USMES in an optimal education program. However, the other

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instruction will be enhanced by the skills, motivation, and understanding provided by real problem solving, and, in some cases, work on an USMES challenge provides the context within which the skills and concepts of the major subject areas find application.

In order for real problem solving taught by USMES to have an optimal value in the school program, class time should be apportioned with reason and forethought, and the sequence of challenges investigated by students during their years in elementary school should involve them in a variety of skills and processes. Because all activities are initiated by students in response to the challenge, it is impossible to state unequivocally which activities will take place. However, it is possible to use the documentation of activities that have taken place in USMES trial classes to schedule instruction on the specific skills and processes required by the school system. Teachers can postpone the traditional way of teaching the skills that might come up in work on an USMES challenge until later in the year. At that time students can learn the required skills in the usual way if they have not already learned them during their USMES activities.

These basic skills, processes, and areas of study are listed in charts and lists contained in each Teacher Resource Book. A teacher can use these charts to decide on an overall allocation of class time between USMES and traditional learning in the major subject disciplines. Examples of individual skills and processes are also given so that the teacher can see beforehand which skills a student may encounter during the course of his investigations. These charts and lists may be found in section E.

Ways In Which USMES Differs From Other Curricula

As the foregoing indicates, USMES differs significantly from other curricula. Real problem solving develops the problem-solving ability of students and does it in a way (learning-by-doing) that leads to a full understanding of the process. Because of the following differences, some teacher preparation is necessary. Some teachers may have been introduced by other projects to several of the following new developments in education, but few teachers have integrated all of them into the new style of teaching and learning that real problem solving involves.

1. <u>New Area of Learning</u>--Real problem solving is a new area of learning, not just a new approach or a new content within an already-defined subject area. Although many subject-matter curricula

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include something called problem solving, much of this problem solving involves contrived problems or fragments of a whole situation and does not require the cognitive skills needed for the investigation of real and practical problems. Learning the cognitive strategy required for real problem solving is different from other kinds of learning.

3. Interdisciplinary Education--Real problem solving integrates the disciplines in a natural way; there is no need to impose a multi-disciplinary structure. Solving real and practical problems requires the application of skills, concepts, and processes from many disciplines. The number and range of disciplines are unrestricted and the importance of each is demonstrated in working toward the solution of practical problems.

3. Student Planning--To learn the process of problem solving, the students themselves, not the teacher, must analyze the problem, choose the variables that should be investigated, search out the facts, and judge the correctness of the hypotheses and conclusions. In real problem-solving activities the teacher acts as a coordinator and collaborator, not as an authoritative source of answers.

4. Learning-by-Doing--Learning-by-doing, or discovery learning as it is sometimes called, comes about naturally in real problem solving since the problems tackled by each class have unique aspects; for example, different lunchrooms or pedestrian crossings have different problems associated with them and, consequently, unique solutions. The challenge, as defined in each situation, provides the focus for the children's hands-on learning experiences, such as collecting real data; constructing measuring instruments, scale models, test equipment, etc.; trying their suggested improvements; and (in some units) preparing reports and presentations of their findings for the proper authorities.

5. Learning Skills and Concepts as Needed--Skills and concepts are learned in real problem solving

as the need for them arises in the context of the work being done, rather than having a situation imposed by the teacher or the textbook being used. Teachers may direct this learning when the need for it arises, or students may search out information themselves from resources provided.

6. Group Work--Progress toward a solution to a real problem usually requires the efforts of groups of students, not just individual students working alone. Although some work may be done individually, the total group effort provides good opportunities for division of labor and exchange of ideas among the groups and individuals. The grouping is flexible and changes in order to meet the needs of the different stages of investigation.

7. Student Choice--Real problem solving offers classes the opportunity to work on problems that are real to them, not just to the adults who prepare the curriculum. In addition, students may choose to investigate particular aspects of the problem according to their interest. The variety of activities ensuing from the challenge allows each student to make some contribution towards the solution of the problem according to his or her ability and to learn specific skills at a time when he or she is ready for that particular intellectual structure.

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B. General Papers on Soft Drink Design

1. OVERVIEW OF ACTIVITIES

Challenge:

Invent a new soft drink that is popular and can be produced at a low cost.

Possible Class Challenges:

Design an inexpensive soft drink to serve at a class party.

Invent a new soft drink to sell in the cafeteria as an alternative to milk.

The idea of devoting class time to the design and production of a new soft drink seems to excite children at all grade levels. The challenge to make a new soft drink may be introduced on a warm day when the children are thirsty or during a discussion of refreshments to serve at a school party or class function.

Students often begin by dividing into groups and randomly mixing drinks. They soon realize the importance of recording recipes and accurately measuring ingredients when they try tc duplicate a good-tasting drink. Debates of why some mixtures taste better than others lead children to identify important characteristics of soft drinks. They may conduct a survey to determine preferences for flavor, color, temperature, and degree of carbonation. Results are tallied and displayed on bar graphs or histograms.

After surveying for preferences of certain soft drink brands, children are sometimes curious about people's ability to distinguish between tastes of different brands of similar drinks, such as colas. One group of students may conduct a blindfold taste test and tally right and wrong guesses on a confusion matrix. Survey results are then reanalyzed.

Intermediate-grade children with ability in mathematics may rate commercial drinks according to their degrees of similarity. They may then construct and analyze drink similarity maps to determine important taste factors to be included in a new drink.

By analyzing and correlating their data, students can figure out which characteristics should be included in a popular beverage. Once new drink recipes have been developed, the class often selects the "best" one by blindfold testing.

When the children mix their drink in large quantities, they use many math calculations and measuring skills. In trying to meet the challenge to produce an inexpensive drink, they may also use comparative shopping and cost analysis to find the best buys for ingredients. Should a class decide to market their drink, the students must determine production cost, selling price, profit, and expected volume of sales. The production and sale of a new drink can lead to problems dealt with in Consumer Research, Manufacturing, and Advertising.

Although many of these activities may require skills and concepts new to the children, there is no need for preliminary work on these skills and concepts because the children can learn them when the need arises. In fact, children learn more quickly and easily when they see a need to learn. Consider counting: whereas children usually learn to count by rote, they can, through USMES, gain a better understanding of counting by learning or practicing it within real contexts. In working on Soft Drink Design children usually learn and practice graphing, measuring, working with decimals, and dividing. Although dividing seems necessary to compare fractions or ratios when figuring unit costs of soft drinks and/or unit costs of ingredients needed, primary children can make these comparisons graphically. Sets of data can also be compared graphically (e.g., line charts of several sets of data on preferences). Division may be introduced during calculation of percentages, averages, or unit costs.

2. CLASSROOM STRATEGY FOR SOFT DRINK DESIGN

The Soft Drink Design unit revolves around a challenge--a statement that says, "Solve this problem." Its success or failure depends largely on (1) the relevance of the problem for the students and (2) the process by which they define and accept the challenge. If the children see the problem as a real one, they will be committed to finding a solution; they will have a focus and purpose for their activities. If the students do not think the problem affects them, their attempts at finding solutions will likely be disjointed and cursory.

The Soft Drink Design challenge--"Invent a new soft drink that is popular and can be produced at a low cost"--is general enough to apply to many situations. Students in different classes define and reword the challenge to fit their particular reason for developing a new soft drink and thus arrive at a specific class challenge. For example, some classes have restated the challenge in terms of inventing a soft drink that could be sold in the school cafeteria or inventing a Kool-Aid drink for a class party.

The Process of Introducing the Challenge

Given that a Soft Drink Design problem exists, how can a teacher, without being directive, help the students identify the challenge that they will work on as a group? There is no set method because of variations among teachers, classes, and schools and among the USMES units themselves. However, USMES teachers have found that certain general techniques in introducing the Soft Drink Design challenge are helpful.

One such technique is to turn a spontaneous discussion of some recent event toward a related Soft Drink Design challenge. For example, a discussion about an upcoming school function could lead to the challenge, or children's complaints about their thirst on a hot day or after recess could lead to a discussion of drinks and then to a Soft Drink Design challenge.

During a class discussion of school parties, a fifth-grade teacher mentioned that while there was usually a good supply of food, there rarely seemed to be enough drinks. The children suggested bringing drinks from home and bringing mixes to prepare drinks at school as possible remedies to the problem. After many children related their experiences mixing their own drink concoctions, the teacher challenged the class to develop an inexpensive and popular drink that could be served at the Christmas party.

Following their recess time on a hot day, students in a combined second/third-grade class lined up for drinks at the classroom water fountain. As the children gathered in the front of the room for a language arts lesson, the teacher asked, "Whatever would we do without a water fountain in our room?" The children offered several suggestions, including one boy's response, "Drink pop." As the conversation then turned to different kinds of soft drinks the children liked, the teacher found it an ideal time to pose the Soft Drink Design challenge. The children were so enthusiastic that they agreed to bring in ingredients to start mixing new drinks the next day.

Sometimes work on another challenge may lead to a Soft Drink Design challenge. For example, children who are working on a Consumer Research challenge may first decide to test soft drinks and then want to invent their own new drink, or children investigating Eating in School may discover a need for another drink in the school cafeteria.

When children working on one challenge do encounter a problem that leads to a related Soft Drink Design challenge, one group of children may begin work on the second challenge while the rest of the class continues with the first challenge. However, there should be at least ten to twelve students working on any one challenge; otherwise, the children's work may be fragmented or superficial or may break down completely.

Sometimes the discussion of a broad problem may encompass the challenges of several related units. For example, a discussion of ways to raise money for a class function, such as a field trip or party, may lead to Soft Drink Design, Manufacturing, or Growing Plants challenge. Similarly, a discussion about ways to improve a school party could lead to Soft Drink Design, Using Free Time, or Eating in School as specific problems are identified.

During a class discussion about school parties, a combination fourth/fifth-grade class suggested various ways they could make the parties more fun and more creative, for example, writing original skits and inventing new games, drinks, and food. When the students voted on which aspect they would work on for their Christmas party, approximately half decided to invent a new party drink while the others chose to design new games.

An experienced USMES teacher is usually willing to have the children work on any one of the several challenges that may arise during the discussion of a broad problem. While this approach gives the children the opportunity to select the challenge they are most interested in investigating, it does place on the teacher the additional responsibility of being prepared to act as a resource person for whichever challenge is chosen.

Classroom experience has shown that children's progress on Soft Drink Design may be poor if the teacher and students do not reach a common understanding of what the challenge is before beginning work on it. Having no shared focus for their work, the children will lack the motivation inherent in working together to solve a real problem. As a result, they may quickly lose interest.

A similar situation occurs if the teacher, rather than insuring that the children have agreed upon a challenge, merely assigns a series of activities. Although the teacher may see how these activities relate to an overall goal, the children may not.

A fifth-grade teacher started the Soft Drink Design unit with a class discussion about the definition of a soft drink, but a challenge was never introduced. Instead, the children pursued a series of fragmented assignments: designing a container for a soft drink, taking a preference survey of the school, conducting a blindfold taste test, and making a soft drink for a party. Although they were interested in the activities, the class was not conscious of any purpose behind them. There were no follow-up discussions nor evaluations, and the children were not working toward the solution of a problem that was real to them. Thus, without being issued a challenge, the children were merely involved in a teacher-directed study about soft drinks.

These problems can be avoided if the teacher issues the challenge at a time when the students have shown some need to develop a new soft drink or when a discussion of drinks arises naturally in the class.

Initial Work on the Challenge

Once a class has decided to work on a Soft Drink Design challenge, USMES sessions should be held several times a week but they need not be rigidly scheduled. When sessions are held after long intervals, students often have difficulties remembering exactly where they were in their investigations and their momentum diminishes.

When students begin work on a Soft Drink Design challenge, they may first list important characteristics of a soft drink (e.g., flavor, sweetness, carbonation). They may also consider surveying others in the school to determine taste preferences and mixing new drinks to taste and compare. After categorizing the suggested ideas and grouping similar ideas together, the children set priorities for the tasks they consider necessary to help solve the problem.

Often children divide into groups to carry out their work. For example, students mixing drinks often work in small groups as they experiment with different types of ingredients. In addition students who are inventing a new drink to sell to other students may form groups to work on various marketing aspects, such as selecting a drink name, determining the method of bottling or distribution, handling finances, and devising an advertising campaign. It is important that the students assign priorities to the various tasks that they plan to perform so that some groups do not become stalled in their progress because others have not completed their work.

> *One class of primary students decided to sell their soft drink. Before they had determined such factors as name, color, price, or quantity to produce, they divided into nine groups. Because so many groups were dependent on other groups providing them with information, there was a great deal of lost time and energy spent trying to accomplish their work. Student interest waned, and it took much effort from the teacher to regain the enthusiasm of the class for following through with their original plan to sell their drink.*

Work can also become fragmented if too many groups are formed. The teacher then finds it impossible to be aware of the progress and problems of each group; in addition, the small number of students in each group lessens the chance for varied input and interaction.

Refocusing on the Challenge

As a class works on a Soft Drink Design challenge, the children's attention should, from time to time, be refocused on that challenge so that they do not lose sight of their overall goal. Refocusing is particularly important with younger children because they have a shorter attention span. Teachers find it helpful to hold periodic class discussions that include group reports. Such sessions help the students review what they have accomplished and what they still need to do in order to find some solution to the problem. These discussions also provide an opportunity for students to participate both in evaluating their own work and in exchanging ideas with their classmates. (Another consequence of having too many groups is that not every group can be given enough time to report to the class, thereby increasing the possibility that the children's efforts will overlap unnecessarily.)

Resources for Work on the Challenge

When children try to decide on solutions before collecting and analyzing enough data or when they encounter difficulties during their investigations, an USMES teacher helps out. Instead of giving answers or suggesting specific procedures, the teacher asks open-ended questions that stimulate the students to think more comprehensively and creatively about their work. For example, instead of telling students who are developing new drink concoctions that they should measure ingredients and record recipes, the teacher might ask, "Can you make another drink that tastes exactly the same so that we all can taste it?" Examples of other nondirective, thought-provoking questions are listed in section B-6.

The teacher may also refer students to the "How To" Cards, which provide information about specific skills, such as using a stopwatch or drawing graphs. A list of those "How To" Cards pertinent to Soft Drink Design can be found in section D-1. If many students, or even the entire class, need help in particular areas, such as using fractions, the teacher should conduct skill sessions as these needs arise. (Background Papers provide teachers with additional information on specific problems associated with some challenges and on general topics applicable to most challenges.)

USMES teachers can also assist students by making it possible for them to carry out tasks involving hands-on activities. For example, if the children need to collect data outside their classroom--at local stores or in other classrooms--the teacher can help with scheduling and supervision. If the children's tasks require them to design and construct items, such as a drink sales booth, the teacher should make sure that they have access to a Design Lab. Any collection of tools and materials kept in a central location (in part of the classroom, on a portable cart, or in a separate room) can be called a Design Lab.

Valuable as it is, a Design Lab is not necessary to begin work on a Soft Drink Design challenge. The Design Lab is used only when needed, and, depending on the investigations decided on by the children, the need may not arise at all. For example--

A second-grade class worked successfully on the Soft Drink Design unit without the use of a Design Lab. Questionnaire results led to a blindfold test for which the children volunteered to bring in soft drinks. When the students had collected enough data *to start mixing drinks, they brought in the necessary ingredients from home. The teacher supplied 100 small paper cups, stirrers, and pitchers to hold water. On mixing day she set up tables and arranged the ingredients so that every five or six children had the same supplies. Several children brought in special ingredients they wanted to use individually. After groups of children had completed the mixing, tasters were brought in from other classes and, on the basis of a taste test, one drink was declared the most popular.*

A combined fourth- and fifth-grade class did all their mixing for the Soft Drink Design unit in the classroom. The children made lists of necessary ingredients and supplies and signed up to bring them from home. The teacher volunteered to buy a few things that the students couldn't supply. The children set up the supplies in the classroom in the morning and mixed drinks in the afternoon. Drinks they wanted to save were stored in the school refrigerator. When everyone was ready, judges, chosen at random from the class, participated in a blindfold test, and the five top drinks were served at the class party.

To carry out construction activities in schools without Design Labs, students may scrounge or borrow tools and supplies from parents, local businesses, or other members of the community.

The extent to which any Design Lab is used for Soft Drink Design varies with different classes because the children themselves determine the direction of the investigations and because construction activities are more likely to be needed for some class challenges than for others.

Culminating Activities

Student activities on a Soft Drink Design challenge generally continue until the children feel that they have successfully designed a new soft drink. If the new drink is to be served at a class or school function, the class must then determine the amount of drink needed, ingredients needed, and costs, and mix and serve the drink. After the class or school function, the class may evaluate their new drink and discuss what they might do differently if they were to design another new soft drink.

If the class decides to sell their new soft drink, they must set up some system for sales. They may decide to operate a drink stand during certain hours of the school day or they may bottle their drink and take orders. In connection with the sale of the soft drink, students often organize an advertising campaign. When the sale or order-taking is over, the class may evaluate their drink again by surveying others in the school.

3. USE OF SOFT DRINK DESIGN IN THE PRIMARY GRADES

Young children's curiosity is easily aroused by the challenge of the Soft Drink Design unit. The prospect of concocting their own original drink to serve at snack time, a school party, or a class picnic is tremendously exciting to primary children. Although their level of expertise and sophistication may differ from that of older children, primary children will be able to mix drinks, measure ingredients, record recipes, approximate costs, and conduct opinion surveys and tests to determine other people's preferences for soft drinks.

Since young children are naturally egocentric, they may wish to begin mixing new drinks first rather than investigating the drink preferences of others. After they have had the experience of making a drink for themselves, their interest may turn to making a class drink or to surveying others to determine their drink preferences, especially if they decide to sell their soft drink.

During the initial class discussion, the children may tell about drinks they like or dislike and list ingredients that are commonly found in soft drinks. Once the class agrees that they need to experiment by mixing drinks, they may decide to form small groups, work in pairs, or work individually as they mix their drinks. Frequently the teacher supplies the necessary ingredients for the mixing sessions; however, some children may wish to bring ingredients from home, or the class may decide to compile a list of ingredients and appoint a shopping group to buy them.

Mixing sessions are great adventures for primary children as well as being valuable learning experiences. They provide opportunities for sharing and cooperation as the children deal with problems of setting up, cleaning up, and conserving and sharing ingredients. In addition, as the children mix drinks, they develop and practice measuring skills. Students may begin by using nonstandard units, such

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as "papercupsful" or bottlecapsful." When such units lead to difficulties in duplicating drinks, the children may switch to either English or metric utensils. Often during the course of a mixing session, children may wish to know how much liquid a certain container holds. They may then use a standard measuring tool to determine this. In one second-grade class the children wanted to find how much liquid a jar held. To find out, they poured cups of water into the jar until it was full.

During mixing sessions students also get hands-on experience in manipulating fractional measurements of ingredients and thus begin to understand the concept of fractions. One class of third graders learned to use fractions so well while devising their soft drinks that afterwards they taught fractions to older children in a nongraded cooking class.

The need for accurate record-keeping evolves naturally as the children attempt to reproduce their "great" drinks. When students in one second-grade class were unable to duplicate their favorite drinks, they learned "the hard way" that recipes should be recorded. In another class of first and second graders, the children swapped their original recipes and tried to make another person's drink. When the resulting drinks were judged "awful," the children realized their recipes were not accurate, and so they remixed the original drinks and carefully recorded the exact recipes.

The children may express a need for more mixing sessions than the teacher has planned. If possible, enough additional sessions should be scheduled so that the children can discover the necessity for accurate measuring and recording if the drink is to be duplicated.

As they mix drinks, children will frequently ask friends to sample them and give an opinion of the flavor. Debates over the "best" drink often lead to secret balloting on taste tests or to blindfold taste tests. One class of second graders was taught how to use the confusion matrix when the children devised a blindfold taste test to see whether people could tell the difference between a national brand of cola and a supermarket brand.

A class of first and second graders devised an experiment to test whether people's biases about color influenced their preferences for drinks. Using food coloring, they made red and purple drinks from the exact same ingredients. Much to their surprise, the red drink was chosen as the most popular. When the class made a drink to sell to the school, they made sure to use red food coloring.

Surveying techniques can be introduced when the children express a desire to know about other people's preferences for soft drinks. One class of second graders spent several weeks designing and tallying the results of a drink preference survey. In analyzing the results, the children were able to identify color, flavor, temperature, and price preferences, which were then used in designing a class drink. A third-grade class devised a preference survey that included questions about packaging and coloring as well as price and flavor.

Graphing skills may be introduced to primary students as an easy way to see and compare data taken from taste tests or drink preference surveys. Graphs utilizing blocks or pegboards may help primary children visualize the results of their data collection. For example, after one second-grade class conducted surveys to determine what type of soft drink other classes in the school preferred, the results for each class were tallied one by one by stacking the appropriate number of blocks for each type of soft drink. In a later session, the teacher explained how to make bar graphs from the survey results by comparing the "blocks" on the graph paper with the blocks stacked by the children.

Primary children may have difficulty when they attempt to compute the costs of soft drinks they have invented since such computation usually involves division. However, costs can be approximated quite accurately by use of concrete objects. For example, if thirty-two ounces of an ingredient costs $1, the children may separate 100 pennies into thirty-two equal piles and find out that each pile has 3 pennies and that there are 4 pennies left over. Thus, one ounce of the ingredient would cost about 3¢. Alternatively, the children may construct a line graph showing the values of $0 for no ounces and $1 for thirty-two ounces and then interpolate to determine the approximate cost of one ounce. In addition, classes may use pie diagrams to illustrate the steps in successive divisions by two. One second-grade class used pie diagrams in this way to compute the cost of the basic ingredients per bottle of their drink.

In addition to computing the cost of the drinks they have made, children may wish to do comparative shopping for their ingredients at several stores in order to determine the best buy. To compare the prices of different sizes or weights of the same ingredient, the children can construct slope diagrams.

Primary children learn and practice language arts skills while working on Soft Drink Design as they record recipes for their soft drinks and develop surveys of drink preferences. When primary children tally results from surveys, they often find that their questions did not elicit the information that they needed and that they must conduct another survey. One second-grade class, after conducting a survey, realized that although they could determine the most popular type (e.g., pop, Kool-Aid, Tang, juice, punch) of soft drink from their survey data, they could not determine the most popular flavor. They therefore decided to conduct another survey on flavors. In addition to writing skills, primary children develop listening and speaking skills during class discussions of problems that come up as they work on Soft Drink Design.

Although several primary classes have utilized the Design Lab to construct soft drink tables and stands to use during a soft drink sale, the Soft Drink Design unit does not involve much Design Lab work. However, experience in many schools has shown that primary children are able to work in a Design Lab and can use the power tools with instruction and supervision from adults. Children working on USMES challenges have designed and built such items as tables, chairs, display stands, and boxes from Tri-Wall and lumber.

4. FLOW CHART

The following flow charts present some of the student activities--discussions, observations, calculations, constructions--that may occur during work on the Soft Drink Design challenge. Because each class will choose its own approach to the challenge, the sequences of events given here represent only a few of the many possible variations. Furthermore, no one class is expected to undertake all the activities listed; a class usually works on just one of the aspects represented by the several charts.

The flow chart is not a lesson plan and should not be used as one. Instead, it illustrates how comprehensive investigations evolve from the students' discussion of a Soft Drink Design problem.

Challenge: Invent a new soft drink that is popular and can be produced at a low cost.

Optional Preliminary Activities:

- *Idea for making a new soft drink arising from some school or classroom need.*
- *Another USMES Unit: Eating in School; Consumer Research*

Possible Student Activities:

Class Discussion: Who would use a new soft drink? What flavors are popular in our class?...in the school? How can we find out? How do we make a new soft drink? What ingredients do we need? What are characteristics of soft drinks?

Listing ingredients and apparatus needed, where to get them, outlining mixing and cleanup procedures necessary to make new drinks.

Data Collection: Devising and conducting surveys in school or class to determine preferences for flavors, colors, temperature, sweetness, carbonation of drinks.

(For children with ability in Mathematics. See background paper *DP 3 Determining Taste Factors for Soft Drink Design* for details.)
Data Collection and Analysis: Rating degree of similarity between pairs of commercial drinks. Rating taste factors (e.g., sweetness, fruitiness, carbonation). Constructing and analyzing drink similarity map to determine important taste factors to be included in new drink.

Experimenting in groups to mix new soft drinks that taste good. Using varying proportions of ingredients. Informal taste-testing of various mixtures.

Data Representation: Making charts, bar graphs, and line charts of preferences.

Class Discussion: Groups report. Discussion of ingredients used in good-tasting soft drinks. Discussion of mixing, measuring, and recording procedures needed to duplicate drinks. Analysis of data from informal taste tests and opinion survey to determine most popular flavors, colors, amount of sweetness, etc. Discussion of cost of drinks made. Determination of which characteristics should be included in class drink. Calculation of quantity of drinks needed to conduct taste tests of whole class, etc.

(Continued on next page.)

Planning the next mixing session: supplies needed, setup, cleanup.

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Experimenting in groups to mix a soft drink that can be tested by class and that has chosen characteristics. Using standardized measurements and recording recipes. Making drinks a second time to check accuracy of recipes.

↓

Data Collection: Taste-testing new drinks. Devising a rating system for drinks and rating them in order of preference. Tallying results.

↓

Data Representation: Making charts and bar graphs of preferences.

↓

Class Discussion: Groups report. Evaluation of mixing session. Determination that recipe can be duplicated if measurements are accurate. Analysis of data to determine "best" soft drink. Discussion of how to determine costs of drinks mixed in order to determine least expensive drink. Discussion of how to duplicate drink in large quantities.

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Serving drink at party, see Flow Chart A.

Selling drink to others, see Flow Chart B.

FLOW CHART A

Serving Drink at Party

<u>Class Discussion</u>: Making plans to serve drink in quantity at class party, school party, etc. Groups formed.

<u>Data Collection</u>: Computation of quantities of ingredients needed to make large amount of drink.

<u>Data Representation</u>: Constructing chart showing amounts of ingredients needed for various numbers of servings.

<u>Data Collection</u>: Determining costs of drinks mixed by comparative shopping and computation of unit prices. Conversion from one set of measurements to another to find cost of ingredients used in recipes.

<u>Data Representation</u>: Making conversion charts and graphs. Constructing charts, bar graphs, slope diagrams, of costs of ingredients and drinks.

<u>Class Discussion</u>: Groups report. Data evaluation and analysis. Determination of which prices to use, where to shop for ingredients. Data displayed on costs of various drinks. Comparison of drink rating data with drink cost data. Discussion of possible criteria for deciding which drink to use: most popular, least expensive, or some compromise. Determination, by chosen criterion, of soft drink to be used. Determination of amount needed for purchase of ingredients. Groups formed.

Obtaining necessary funds and purchasing necessary ingredients in proper amounts.

Duplicating recipe. Securing equipment for mixing and dispensing drink. Preparing amount of drink needed.

Party held.

<u>Class Discussion</u>: Evaluation of soft drink, suggestions made for improvement.

Optional Follow-up Activities:

Inventing another new soft drink by mixing various soft drinks having important popular taste factors.

Inventing another new drink by mixing two or more of the most popular commercial soft drinks.

Selling drink to others.

Other USMES Units:
Manufacturing
Advertising
Consumer Research

FLOW CHART B

Selling Drink to Others

Class Discussion: Decision made to sell drink to others. Discussion of ways to determine name, possible price for drink, customer demand for drink. Groups formed.

Data Collection: Computation of quantities of ingredients needed to make large amount of drink.

Data Collection: Determining costs of drinks mixed by comparative shopping and computation of unit prices. Conversion from one set of measurements to another to find cost of ingredients used in recipes.

Data Collection: Devising and conducting opinion survey to determine demand, possible price, name for soft drink; tallying survey data.

Data Representation: Constructing chart showing amounts of ingredients needed for various numbers of servings.

Data Representation: Making conversion charts and graphs. Constructing charts, bar graphs, slope diagrams of costs of ingredients and drinks.

Data Representation: Constructing charts, bar graphs, line charts, histograms of survey data.

Class Discussion: Groups report. Data evaluation and analysis. Determination of which prices to use, where to shop for ingredients. Data displayed on costs of various drinks. Comparison of drink rating data with drink cost data. Discussion of possible criteria for deciding which drink to use: most popular, least expensive, or some compromise. Determination, by chosen criterion, of soft drink to be used. Determination of selling price, estimated volume of sales, name for drink. Determination of amount of ingredients and supplies needed based on survey data. Determination of amount needed for purchase of ingredients. Groups formed.

(Continued on next page.)

Obtaining necessary funds and purchasing necessary ingredients in proper amounts.

Duplicating recipe. Securing equipment for mixing and dispensing drink. Preparing amount of drink needed.

Conducting advertising campaign with posters, sandwich boards, intercom announcements. Designing labels for bottles. Utilizing slogans and gimmicks in advertising.

Designing and building soft drink stand, carrier, or dispenser.

Organizing sale: sale area, work schedule, permission for sale, holding a mock sale to determine personnel needed.

Sale held or orders taken.

<u>Class Discussion</u>: Evaluation of soft drink, suggestions made for improvement. Evaluation of sale. Financial report, repayment of loans. Determination of how to spend profits.

Optional Follow-up Activities:

Inventing another new drink by mixing various soft drinks having important popular taste factors.

Inventing another new drink by mixing two or more of the most popular commercial soft drinks.

Other USMES Units:
Manufacturing
Advertising
Consumer Research

5. A COMPOSITE LOG*

This hypothetical account of a primary-level class describes many of the activities and discussions mentioned in the flow chart. The composite log shows only one of the many progressions of events that might develop as a class investigates the Soft Drink Design challenge. Documented events from actual classes are italicized and set apart from the text.

Shortly after the spring vacation, one student asks if there is going to be a party for everyone in the second grade, as there was last year. Other students in the class remark that they hope there will be a party and that they would like to work on planning for it. The teacher says, "I will check with the other teachers as to plans for the party, but first I would like to see how everyone in the class feels about doing the advance planning." After several enthusiastic and positive comments, the class decides to vote on whether or not they should offer to plan the party for their grade. A show of hands indicates that the class is overwhelmingly in favor of the idea. The teacher says that she will check with the other teacher and then let the class know how they feel.

Several days later, the teacher announces that she has discussed the party with the other second-grade teachers and that they are very happy that her class wishes to plan it. She reports that one teacher commented that "maybe this year, if the children do the planning, there will be enough to drink for once!"

The children agree that not having enough to drink is often a problem at parties, and they suggest that soft drinks and Kool-Aid be brought from home. Then one student suggests, "We should make a surprise party punch of our own." The teacher asks if anyone has ever experimented at mixing his or her own soft drink. Many students have and during the course of the discussion share their experiences in using different ingredients.

After this discussion the teacher continues, "I have more news for you--since you are to be in charge of planning the party, the teachers are giving you some money to spend on food and drinks." The students are delighted and agree that they will have to be careful how they spend the money to be sure that they get everything they will need.

One student then observes that making the punch is a good idea because it will also save money. Another student remarks that if the drink is cheap there will be more money for potato chips and ice cream. The teacher asks how they will know if making a punch is cheaper than buying a ready-made drink. One student states that his mother told him that buying syrup and mixing it with water is cheaper than buying canned drinks. "How will we know for sure, though?" asks the teacher.

A girl suggests that the class bring in ingredients such

*Edited by USMES staff

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as mixes and syrups and make some drinks to find out. "I bet we can make a drink everyone will like and still make it cheaper than a store-bought drink," she says. All agree that this is a good idea.

As the class continues to discuss the idea of making a punch for the party, the children suggest flavors and ingredients that they would like to try in the punch. Finally, after many ideas for ingredients and flavors have been brought up, one boy says that so many people have told their ideas that he can't keep track of them all. Another student, with the help of the class, writes the following list of ingredients and flavors on the board:

Flavors	Ingredients
grape	sugar
orange	club soda
cola	jello--lemon, cherry
lemon and lime	Kool-Aid (dry mix)
raspberry	flavored syrups
root beer	real lemon
sprite	soda (different flavors)
	ice

The teacher asks the class to look at the list on the board and try to tell what basic things a good punch or soft drink should have. Several students offer suggestions:

- some good flavor--flavored syrup or dry mix
- sugar
- water
- add soda if desired
- refrigerate

The students all agree that they should next mix some drinks in order to find a good drink to serve at the party. Several children volunteer to bring in ingredients, and the teacher says she will supply the sugar. The teacher asks the class if each person is going to mix his or her own drink. After some discussion, the class decides to divide into five groups according to their favorite flavors--grape, orange, root beer, lemon and lime, and raspberry.

One primary class in Arlington, Massachusetts, became involved in the Soft Drink Design challenge when they found that they needed a drink after play-

ing outside at recess. After discussing several ways to provide a drink for after recess and after lunch, the class voted to bring in ingredients to mix at school. (See log by Mary Lou Rossano.)

One third-grade class in Burnsville, Minnesota, began work on Soft Drink Design after their teacher made a magic Halloween potion. When some of the children told the teacher that they could make a drink that tasted better than the magic potion, she challenged them to do so. (From log by Connie DeMuth.)

In one fifth-grade class in Monterey, California, it was decided to survey others in the school to determine the most popular soda pops before beginning to mix drinks. After finding from their opinion survey that the four top drinks were Coke, orange, 7-Up and root beer, the class divided into three groups to mix soft drinks. (From log by Barbara Dahlberg.)

The next afternoon the class breaks into groups to begin mixing soft drinks. Using various quantities of sugar, water, soda pop, and different kinds of syrups and mixes for flavoring, each group experiments to find a combination that tastes good. Only one group uses a teaspoon to measure ingredients, other groups just pour in a bit and taste the mixture, then pour in more if they feel it is needed. After mixing four or five different combinations, the children in each group taste their combinations to pick the best-tasting drink. Several groups give samples of their drink to other children in the class to see if they think it is a good drink, too.

After everyone has finished making and tasting their drinks, the class gathers to discuss what has happened. All of the groups feel that they made a good drink. But when one child suggests that everyone in the class should taste a drink from each group, the children realize that they have not measured or recorded the amounts of ingredients used and so cannot make the same drink again. They decide that they should have another mixing session so that they can measure and record the ingredients in their drinks.

One boy notes that some groups made carbonated drinks and

others made noncarbonated drinks and that he wants to know whether the party drink should be carbonated or noncarbonated. Some children say that they prefer carbonated drinks, while others say they would rather have a noncarbonated drink.

"How can we decide which would be better?" the teacher asks. One student suggests that each group make both a carbonated and a noncarbonated version of their drink. Another student reminds the class that a noncarbonated drink will cost less because water is free while carbonated water costs money. The class decides by a hand vote to make only noncarbonated drinks.

Near the end of the discussion the children list important points to remember for the next mixing session:

1. Plan ahead--each group should be responsible for bringing utensils and ingredients.
2. Delegate setting up and cleaning up tasks.
3. Measure and record ingredients carefully when mixing drinks.
4. Make about a quart of the drink so that there is enough for everyone to taste-test.

At the next mixing session, things go more smoothly. The children remember to measure ingredients and record recipes. Some groups use big paper cups marked in inches on the side or small 1 oz. cups to measure, others use teaspoons and tablespoons. Again, each group makes up several different drinks. Members of each group pick the drink that they like best.

To make a large enough quantity of drink for the whole class, most groups first make several separate servings of their recipes and then combine these servings in a quart jar. The teacher, observing this procedure, asks each group to compare the taste of the different servings to see if they taste the same. The children find that some are very similar in taste while others taste quite different. The teacher asks the children what they can do to make the servings more uniform in taste. The children decide that measuring and recording ingredients more carefully should help.

While mixing drinks in one fifth-grade class in Athens, Georgia, the children in each group made a list of the ingredients and materials that they needed to mix their drink. At their first mixing *session none of the groups measured ingredients or recorded recipes. When the teacher asked if they would need to reproduce their drink, several groups began to develop a measurement system for their ingredients and to record the recipes for the drink they had made. (See log by Janice Turner.)*

The Burnsville class improved their mixing procedures during three consecutive sessions. At the first mixing session, the children wasted ingredients and neglected to measure and record recipes. At the next class session, they discussed these problems, figured the cost of ingredients, and formulated rules to prevent waste. They also realized the need for measuring cups and spoons and for an organized cleanup and suggested that recipes be recorded. During the third session most of the class measured and recorded the amount of ingredients used. When the children were unable to reproduce their old drinks, they decided that measuring and recording must be done more carefully. (From log by Connie DeMuth.)

As each group finishes making their drink, they place their quart jar on a table at the front of the room for the taste test. After a brief discussion they decide to rate each drink "good," "fair," or "poor." They label each bottle of drink with a number and begin the taste test. One student tallies results for each drink, while another pours the samples into cups for tasting.

When all the testing is finished, the students tally the results on the board:

DRINK	GOOD	FAIR	POOR
#1 (Grape)	卌 卌 ||	卌 |	卌
#2 (Orange)	卌 卌 ||	||||	卌 ||
#3 (Root Beer)	||||	卌 卌 ||	卌 ||
#4 (Lemon and Lime)	卌 卌	卌 |||	卌
#5 (Raspberry)	卌	卌 ||||	卌 ||||

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DRINK	GOOD	FAIR	POOR	TOTAL
GRAPE	12 12x2=24	6 6x1=6	5 5x0=0	30
ORANGE	12 12x2=24	4 4x1=4	7 7x0=0	28
ROOT BEER	4 4x2=8	12 12x1=12	7 7x0=0	20
LEMON AND LIME	10 10x2=20	8 8x1=8	5 5x0=0	28
RASPBERRY	5 5x2=10	9 9x1=9	9 9x0=0	19

Figure B5-1

The teacher asks the class which drinks had the most "good" marks. Everyone agrees that grape, orange, and lemon and lime came out better than root beer and raspberry. The teacher then asks why they think the results came out as they did. The class makes many specific comments:

- Root Beer and Raspberry weren't sweet enough.
- Root Beer tastes terrible uncarbonated.
- Grape and Orange had good flavor and sweetness.

The children next discuss how they will choose a winning drink. Because there are two drinks tied for first place ("good" rating), some way must be found to decide between them. After discussing several possible ways to determine the winner, the class decides to give two points for each good rating, one point for each fair rating and zero points for each poor rating, and the drink with the highest number of points will be the winner. The chart in Figure B5-1 shows the analysis, computation, and total score for each drink. Using this method, the class determines that the winner is grape. See Figure B5-2 for the recipe for four 8-oz. servings of the grape drink (determined by multiplying the original recipe by the number of separate servings needed to make 1 quart).

GRAPE DRINK RECIPE

(One quart or four 8 oz. servings)

1 c. grape syrup

3 c. water

2 tsp. lemon juice

Figure B5-2

When the third-grade class in Burnsville decided to taste test other classes to determine which of the drinks they had made was the most popular, the children formed groups to handle various aspects of the test: making a ballot, mixing the drinks (2 groups), taking samples to classrooms (2 groups), graphing results. (From log by Connie DeMuth.)

One fifth-grade class in Lexington, Massachusetts, decided that a fair method of choosing the best drink was to blindfold students who were being tested. While one student poured samples into cups from labeled bottles, another student held up the number of the drink being tasted. The rest of the students kept a tally of the ratings. When the testing was completed, the students added up the good, fair and poor ratings for each drink and converted the votes in each category to percentages. (See log by Robert Farias.)

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Put a circle around your answer.

1. What flavor do you like?

lemon and lime	strawberry
grape	ginger ale
cherry	cola
root beer	orange

2. Do you like sweet drinks? Yes No
3. Do you like very sweet drinks? Yes No
4. Do you like sour drinks? Yes No
5. Do you like watery drinks? Yes No
6. Do you like your drinks cold? Yes No
7. Do you like your drinks warm? Yes No
8. Do you like your drinks hot? Yes No
9. What color do you like? ________

Figure B5-3

Put a circle around each answer

1. Circle your two favorite flavors.

lemon and lime	strawberry
grape	ginger ale
cherry	cola
root beer	orange

2. Should the drink be
   very sweet   sweet   sour
3. Do you like watery drinks? Yes No
4. Should the drink be
   cold   warm.   hot
5. What color do you like? ________

Figure B5-4

The teacher asks the class whether they think other students will agree with their choice of drink. The children realize that they need some method of making sure that most people will like the drink that they make for the party. One student points out that other classes will be at the party and that the drink must be one that they like too.

The teacher asks the class how they can find out what kinds of drinks are preferred by the other second-grade classes. The children make many suggestions:

- We should ask them.
- Give them a list of popular drinks to choose from.
- Ask them to vote on their favorite flavors.
- Make up large amounts of the drinks that we think are best and let other classes taste them, then vote on which they like best.

After discussing these ideas, the class decides that a Questionnaire Group should be formed to first survey their own class and then the other classes. The teacher then asks the class what they think people like in a soft drink, and the class lists the following important factors:

1. Taste or flavor
2. Amount of sweetness or sourness
3. Temperature
4. Color

Several children volunteer to work on writing an opinion survey that will include these factors.

Several days later the Questionnaire Group presents the opinion survey (shown in Figure B5-3) to the class. The children make several suggestions for improving the survey:

- Ask the students to circle their two favorite flavors
- Combine Questions #2, #3, and #4 to read: Should the drink be very sweet   sweet   sour
- Combine #6, #7, #8 same way

Everyone agrees that the suggestions are good, and the group modifies the opinion survey accordingly. (See Figure B5-4.) The children decide that they should make copies of the survey and give it to their own class first as a test. Two children volunteer to make a copy of the survey on a ditto and run off enough copies for the class.

Put a circle around each answer

1. Circle your two favorite flavors.

lemon and lime ||||| || strawberry |||
grape ||||| ||||| ginger ale ||
cherry ||||| ||| cola ||||| |
root beer |||| orange |||||

2. Should the drink be

very sweet ||||| | sweet ||||| ||||| |||| sour |||

3. Do you like watery drinks?   Yes ||||| | No ||||| ||||| |||||

4. Should the drink be

cold ||||| ||||| || warm ||||| | hot ||||

5. What color do you like? ________

purple ||||| |||| red ||||| |
orange ||||| brown |
green ||

Figure B5-5

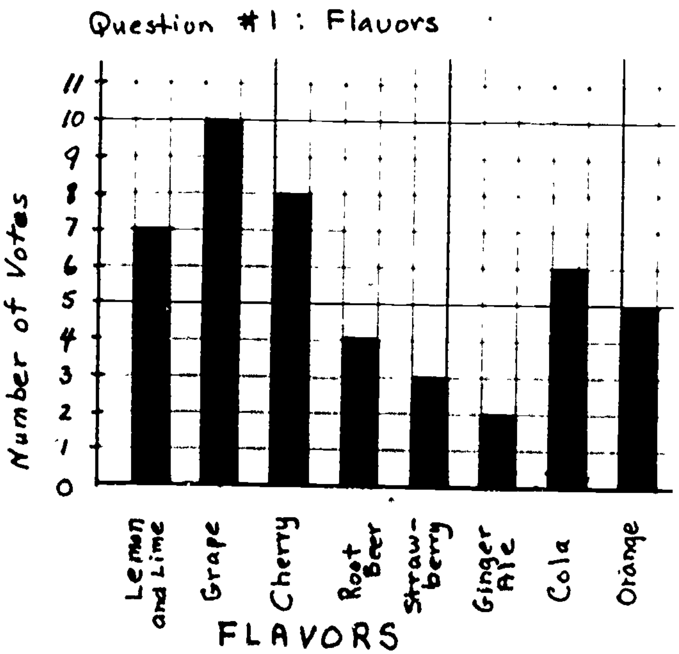

Figure B5-6

When the copies are ready, the children answer the questions. But the Questionnaire Group is not sure what to do with the answers. After the teacher reminds the group of the purpose of the survey, one boy suggests going over all the papers and adding up all the answers that are the same for each question. The group then begins to tally responses to the survey on the board, working with one question at a time. When the group finishes their tallying, the results are as shown in Figure B5-5.

The teacher asks the class if they can tell which flavor was liked by most people. The children see that grape got the most votes, followed by cherry and by lemon and lime. These flavors are listed on the board. Next, the class discusses the second question. One girl says, "Most people like a drink sweet but not very sweet. It is better to have it very sweet than sour. We need to use sugar in our drinks."

After discussing each question, the class ends up with the following list on the board:

1. Flavor--use grape, cherry, lemon and lime
2. Sweet--use sugar but not too much
3. Watery--no, don't use too much water
4. Cold--use ice or refrigerate
5. Color--purple

The teacher asks whether there is some way the class can display their data more clearly. The children offer many suggestions for pictures and charts and the teacher then tells the class about bar graphs. The children are eager to try making bar graphs of their data. They break into groups to make bar graphs for four of the questions (1, 2, 4, 5). Some of the results of their work are shown in Figures B5-6 and B5-7.

The students then talk about how they can improve the opinion survey. All agree that the main problems seem to be that some people didn't answer all of the questions and that others circled two answers for some questions. The class decides to change the directions to say: Circle *one answer* for each question except #1. They also list five colors under Question #5.

In one fifth-grade class in Chicago, Illinois, the children prepared an opinion survey asking people to list their favorite soft drink. When the class began tallying the survey results, some of the chil-

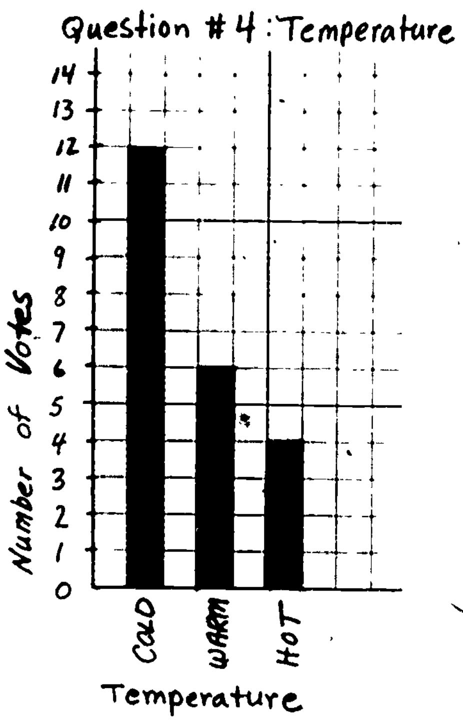

Figure B5-7

dren noticed that many responses only listed a flavor such as orange or grape but did not indicate whether juice or soda was meant. After much deliberation, the class decided that there was an error in the wording of the survey. They rewrote the questions to include a choice between soda and juice and conducted the survey again. (From log by Erwin Drechsler.)

In one second-grade class in Eaton Rapids, Michigan, the children questioned whether all soft drinks contain sugar, whether malts and juices should be included, and whether a soft drink must be carbonated. To determine which types of drinks they should make, the class decided to ask as many people as possible what they thought. After taking an informal opinion survey, the children decided that soft drinks should include such things as lemonade, juice, Kool-Aid, malts, pop (soda), and punch, and that they did not necessarily have to be carbonated. They then decided to survey others in the school to determine which drinks were preferred and, therefore, what sort of soft drinks they should make. (From log by Barbara Mazany.)

After a student goes around to the other second-grade classrooms to find out how many students are in each classroom, the class runs off the necessary number of revised surveys, and students go to each of the other three classrooms to conduct the survey. The Questionnaire Group tallies these surveys with the following results:

1.	Flavors	lemon and lime	28	strawberry	6
		grape	23	ginger ale	7
		cherry	10	cola	18
		root beer	17	orange	33

2. Very sweet 16 sweet 45 sour 10
3. Watery YES 54 NO 17
4. Cold 57 Warm 12 Hot 2
5. Color Purple 26 Orange 12
   Red 22 Green 8
   Brown 3 .

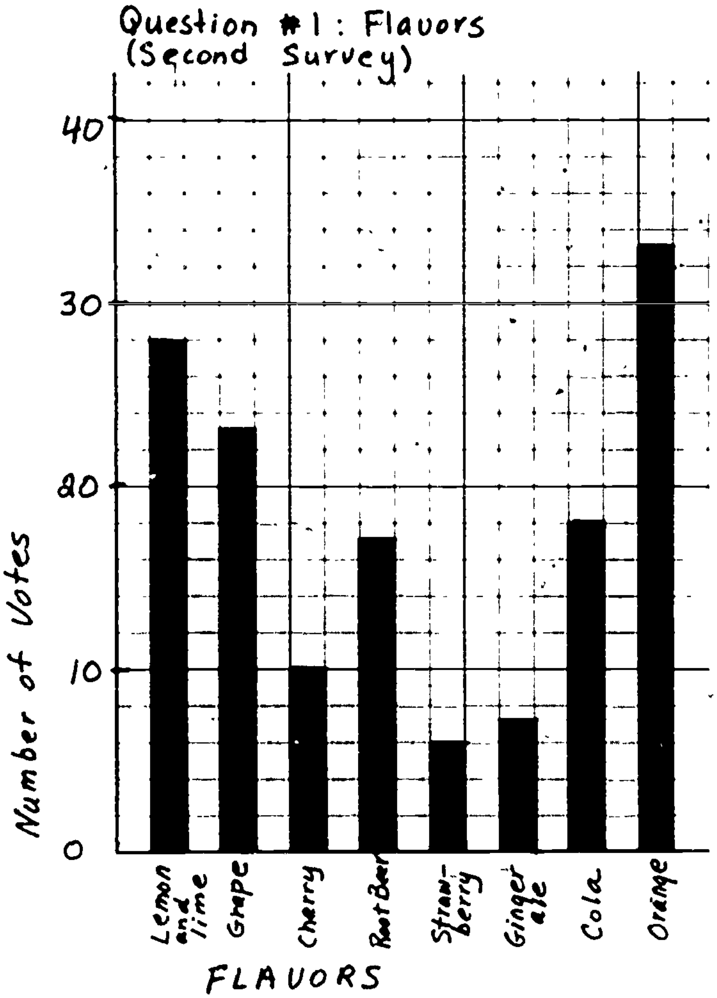

Figure B5-8

The class looks at the results and compares them with the survey of their own class (see Figure B5-5). They notice that the results are identical except for flavors. To help them decide on a flavor, the class makes a bar graph showing the flavors from this survey to compare with their first bar graph on flavors. (See Figure B5-8.)

In a fifth-grade class in Carmel, California, the students organized their survey data on their own, with one student tallying the totals from one category at a time on the chalkboard as others read the results from the sheets. Two other students kept a written record of the results at their desks. When the data had been completely recorded, the chalkboard was covered with hundreds of tally marks under the survey categories. After some students complained that the tally marks were hard to understand, the teacher asked the class to think of other ways to display the data. The children suggested (and later made) several types of bar graphs and line charts. (From log by Raymon Wilson.)

When a seventh-grade class in Athens, Georgia, compared opinion survey results on drink preferences from four other classes with results from their own class, the students noticed that the preferences from their class were very different from those of the other classes. After discussing why this should be so and concluding that different people like different things, the students decided to conduct a taste test to determine whether they could actually distinguish one drink from another. (From log by Ida Campbell.)

At their next session, the children discuss how they can choose three drinks for the final mixing session before choosing the drink they will serve at the party. They discuss the following points:

- On the taste test, grape won; orange and lemon and lime tied for second place.

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- On the class preference survey, the top three flavors were grape, lemon and lime, and cherry.
- On the survey of the other second-grade classes, the top three flavors were orange, lemon and lime, and grape.

Because cherry was listed only once in the top drinks, the class decides to eliminate it and to mix drinks with grape, lemon and lime, and orange flavors.

Working in three groups, the children use the old recipes that they have for each flavor and also try some new combinations. Each group taste tests their drinks and picks the best one, carefully recording the recipe. At the end of the mixing session each child tastes the three drinks and rates them good, fair, or poor. The class finds that while the orange drink does not taste very good, the grape and lemon and lime drinks are delicious. The children discuss how they can choose between these two drinks and decide to make the cheaper one.

In order to decide which five drinks out of the more than forty drinks mixed were to be served at their party, the Carmel class selected seven judges to taste test the drinks, and set up the following procedure for the testing:

- *Blindfold judges*
- *Judges rate each drink good or bad as they taste it*
- *Another student records responses*

Five drinks were rated as good by all seven judges and it was decided that these drinks should be produced in quantity and served at the party. (From log by Raymon Wilson.)

In the Eaton Rapids class the children decided that students from another class should decide which drink was the best. All the drinks were placed on the windowsill and five children from the other class tasted each drink and marked the ones they preferred. Five different children then tasted the four drinks that had been marked and chose one as the final drink. (From log by Barbara Mazany.)

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Grape Syrup (Store brand)
16 oz. $.67
32 oz. $1.21

Grape Syrup (ZaRex)
16 oz. $.79
32 oz. $1.59

Sugar
5 lbs. $1.00

Lemonade mix
3 oz. package 2 for $.43

Lemon and lime syrup (Store brand)
16 oz. $.65
32 oz. $1.15

Figure B5-9

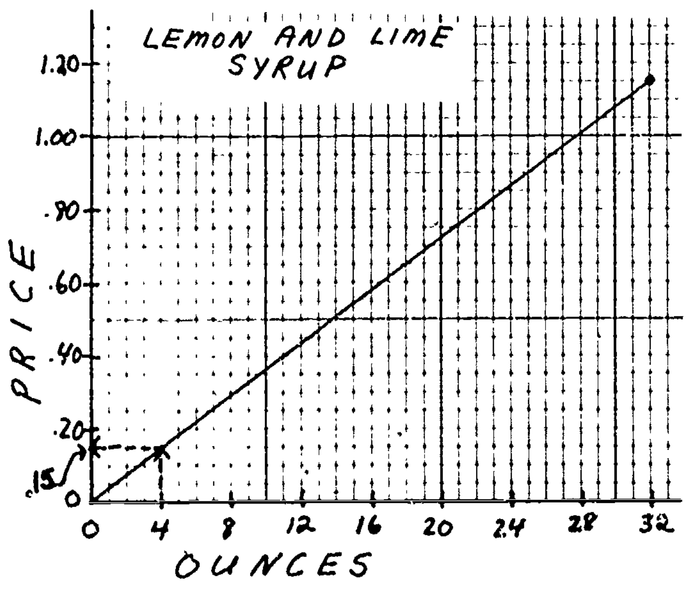

Figure B5-10

To calculate the cost of each drink, the students first list the ingredients needed for each drink:

Grape Drink (4 servings)	Lemon and lime Drink (4 servings)
1 cup grape syrup	3 oz. package of lemonade mix
3 cups water	½ cup sugar
2 Tablespoons (1/8 cup) sugar	½ cup lemon and lime syrup
	3½ cups water

One boy comments that to find the cost, the class must find out how much each ingredient costs in the supermarket. Several children volunteer to visit different stores after school to check the prices.

The next day, some of the children bring in lists of ingredients with their prices. (See Figure B5-9 for one such list.) After looking at the lists, the class decides to use the price of $1.21 for the 32-oz. (one quart) size of grape syrup in the calculations. As they have already found that 8 oz. (liquid) = 1 cup, they change the liquid cup measurements in the recipes to ounces:

Grape Drink (4 servings)	Lemon and Lime Drink (4 servings)
8 ounces grape syrup	3 oz. package of lemonade mix
24 ounces water	½ cup sugar
2 Tablespoons sugar	4 ounces lemon and lime syrup
	28 ounces water

The class realizes that division is needed to do much of the computation, and they ask the teacher if she will figure the costs for them. Instead, the teacher shows them how to make a line graph and makes one for the grape syrup as an example. The class finds from this graph that 1 cup (or 8 oz.) of grape syrup will cost about 30¢. The children then make a line graph for the lemon and lime syrup and find that 4 oz. will cost about 15¢. (See Figure B5-10.)

To compute the cost of the sugar, the children first find out that there are 16 oz. in 1 lb. They figure that 5 lb. is going to be 5 x 16 oz. They add 16 five times and find that 5 lb. is the same as 80 oz. of sugar, which costs $1.

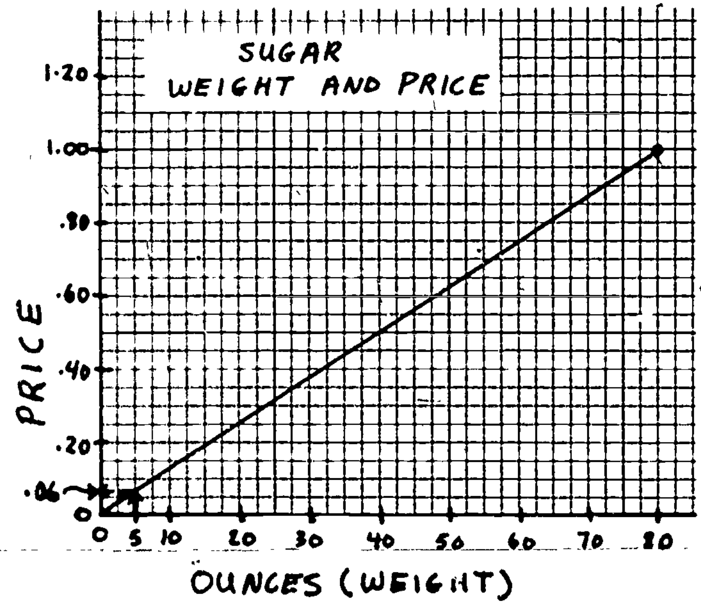

Figure B5-11

One student asks the teacher whether 8 oz. of sugar equals one cup of sugar. The teacher explains that there are two kinds of ounces, one for measuring volume, called a fluid ounce, and another for measuring weight, called an ounce. The 80 oz. they calculated from pounds tells its weight rather than its volume. She then asks the class if they can think of a way to find out whether one cup of sugar weighs 8 oz. The students decide to weigh a cup of sugar to find out. They discover that one cup weighs 9½ oz., ½ cup weighs about 5 oz., and two tablespoons weigh a bit more than 1 oz.

The teacher shows them how to construct a line graph of weight vs. cost for the sugar. (See Figure B5-11.) The children find from the graph that ½ cup of sugar (5 oz.) costs about 6¢ and that two tablespoons (1 oz.) cost about 1¢.*

The class lists the costs for all ingredients in each recipe and adds them to find the cost of four servings for each drink:

Grape Drink (4 servings)	
8 fluid ounces grape syrup	.30
24 fluid ounces water	--
2 Tablespoons sugar	.01
Total cost	.31

Lemon and Lime Drink (4 servings)	
3 ounce package lemonade mix	.22
½ cup sugar	.06
4 ounces lemon and lime syrup	.15
28 ounces water	--
Total cost	.43

Since the grape recipe costs less, the class unanimously picks grape as the drink for the party.

Figuring that there will be nearly 100 children at the party, the class computes the cost of giving 2 servings to each child (or 200 servings in all) to be fifty batches of 4 servings each or 50 x $.31 = $15.50. Because this seems too costly, the children decide to provide only 100 servings (25 batches of 4 servings each) at a cost of $7.75.

The teacher helps the children figure the amount and cost of each ingredient needed to make 100 servings:

*Students who know how to divide would do the necessary division and get more accurate amounts.--ED.

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Grape Drink
(100 servings)

200 fluid ounces grape syrup	(8 fluid ounces x 25)
600 fluid ounces water	(24 fluid ounces x 25)
25 ounces sugar	(1 ounce x 25)

Because each bottle of grape syrup holds 32 fluid ounces, the class calculates how many bottles will be needed for 200 fluid ounces. The teacher suggests that the class add up 32s until they reach 200. One boy finds that six 32s add up to 192 and that 8 more fluid ounces are needed to make 200 fluid ounces. The children decide that they should buy six 32-oz. bottles and an additional 16-oz. bottle of grape syrup to get enough syrup for 100 servings. To get 25 ounces of sugar, the class plans to buy a 32-oz. (2 lb.) package of sugar, which costs 45¢.

The children figure the costs as follows:

Grape Syrup		1.21
6 bottles at \$1.21	\$7.26	1.21
1 bottle at \$ .67	.67	1.21
Sugar	.45	1.21
		1.21
Total cost	\$8.38	1.21
		7.26

Several children then volunteer to bring the necessary amounts of sugar and syrup.

A combination fourth/fifth-grade class in Lansing, Michigan, compared the costs of three drinks they had invented. All the groups knew what had to be done to find the costs but did not have the math skills to do the computation. The teacher worked with the students and together they compiled a price list of all of the ingredients used by the groups:

Kool-Aid (with sugar)	*5/16¢ per tablespoon*
Tang	*2-1/2 ¢ per tablespoon*
Lemon Juice	*1/2 ¢ per teaspoon*
Coke	*1 ¢ per ounce*
7-Up	*2 ¢ per ounce*
Club Soda	*1-2/7 ¢ per ounce*

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After the three groups found the cost of their recipes, they figured the cost per gallon and consequently the cost of a 7-oz. cup. (From log by Carol Allen.)

The cost committee of the Carmel class computed the cost of an 8-oz. serving of their drink to be 4.5¢ for the ingredients and 6.85¢ with the paper cup costs included. (From log by Raymon Wilson.)

The day before the party, the children hold a giant mixing session. The class divides into five groups with each group mixing the drink in batches to make twenty servings. (The recipe used is five times the original recipe.) The drink is stored in the refrigerator in half-gallon jugs.

After the party, the children discuss the results of their work. The class feels that the party and the grape drink were a great success. Several children report that many others commented on how good the drink was. During this discussion the teacher asks the class if they would like to tell what they have learned so far from making a drink for the party. Some of the children's comments are as follows:

- How to measure
- How to work together and share jobs
- How to find the best buy
- How to figure the cost of a drink
- How to make a drink others will like
- How to write a recipe
- How to make up an opinion survey

The Eaton Rapids class held a party on the last day of school at which their drink was served. The class formed groups to work on different aspects of the party, with one group completely responsible for the mixing and serving of a large quantity of the drink. The class as a whole was very proud of the drink they had made. (From log by Barbara Mazany.)

Because of suggestions from other students, several days after the party the children discuss the possibility of sell-

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ing the drink. After many ideas are brought up, the children list the following things to be done before selling the drink:

- taste test other grades (besides second grade)
- survey to find price others will pay
- find out where and when to sell drink
- find out how to sell it--in bottles or cups
- get permission to sell it
- make up a name for the drink

The students decide to form groups to work on these ideas in preparation for selling the drink.

When the Athens class decided to sell their new drink, they first met in groups to consider many questions in regard to organizing the sale. Near the end of the class period, the groups pooled their ideas and developed the following plan:

1. *Ingredients needed: 30 Sprite*
   30 7-Up
   660 drops red food color
2. *Prepare cups of drink ahead of time (need 180 cups).*
3. *Customers would come to room, pay cashier at door, pick up drink, and go into next room to drink it.*
4. *Ice should be provided.*
5. *For cleanup a large trash can would be needed near the door.*

(From log by Ida Campbell.)

6. QUESTIONS TO STIMULATE FURTHER INVESTIGATION AND ANALYSIS

- Have you ever made your own soft drink? How? What ingredients did you use to make it?

- How many different kinds of soft drinks can you think of? What is the same about them? What is different about them?

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- What kinds of soft drinks should we make? How can we make a drink that everyone likes?

- What is your favorite drink? What are other people's favorite drinks?

- How many different flavors can you think of? What flavors are most popular? What flavors should we/you use? How can you find out?

- Are all soft drinks sweet? Should our drinks be sweet? How sweet? How can you find out?

- Should our drinks be carbonated or noncarbonated? Do people like carbonation? How can you find out?

- Are soft drinks usually warm, hot, or cold? Which temperature of soft drink tastes better? How can you find out? What will you need to do to make your drink cold? ....hot?

- What can you find out from a preference survey on flavors, colors, sweetness, carbonation, temperature, etc.?

- What is a good way to show the results of your opinion survey? How can you show the data clearly? How can you make a picture of the data?

- How can you tell from your survey data what characteristics a "good" drink should have?

- How many new soft drinks should we mix? What ingredients will we need? How can we get them? How much do we need? What other materials could we use to mix drinks?

- What arrangements should we make for setting up and cleaning up our mixing areas? How can we avoid wasting ingredients?

- How can we keep track of what ingredients, and how much of each, we use when we mix drinks? What kind of measurements (e.g., ounces, ml, cups) and measuring tools should we use?

- How can we find out if our drink is good? How can we pick a good drink without being influenced by our own drink or by our friends' drinks?

- Do you think that people might pick one type of drink on an opinion survey and another type of drink on a taste test? Why might this happen?

- How can we duplicate our "good" drinks? Why might different batches of the same soft drink taste different?

- How can we find out if people can tell the difference between certain popular soft drinks?....between the drinks we have made?

- Should we make our drink for ourselves or for others too? Should we sell our drink?

- How many servings of our drink should we make? How can we make large quantities of our drink? How should we serve our soft drink (in bottles, cups)?

- How can we find out how much our drink costs to make? How can we figure out the total cost of ingredients?....the cost per unit of ingredients? Where can we buy ingredients at a low price? How can we find out where to get the best buy for the money?

- What do we need to know before we decide to sell our soft drink? How much would people pay for our soft drink? How can you find out? Where and when should we sell our drink? How much should we charge (per serving) for our drink?

C. Documentation

1. LOG ON SOFT DRINK DESIGN

by Mary Lou Rossano*
Hardy School, Grade 2
Arlington, Massachusetts
(October 1973-June 1974)

ABSTRACT

This second-grade class spent approximately two hours per week from October to June working on a Soft Drink Design challenge to develop a snack-time drink that everyone in the class would like. Unable to duplicate drinks they had made during random mixing, the children realized the importance of accurately measuring ingredients and recording recipes. They devised a class questionnaire on drink preferences, tallied the results on a master chart, and then worked for several months in four groups to develop drinks that fit the survey criteria for a popular drink. Student interest in Soft Drink Design was so great that, on their own, the children began drawing pictures and writing stories about their activities, and several even stayed after school to work on a mural. When one drink was voted the most popular, the students decided to sell it to other classes. The Mixing Group scrounged and cleaned quart jars for mixing and bottling large quantities of "Super Grape," and they devised an order form. The Advertising Group developed slogans, made posters and announcements, and designed labels for bottles. The Drink Stand Group had difficulty obtaining supplies for their stand and ended up constructing a table for the classroom. Before selling their drink, the class used pie graphs to perform a cost analysis and figure profit per bottle. Sales of Super Grape continued for six weeks. The second graders used half their profits to buy a plant for a nearby nursing home and half to treat everyone in class to ice cream cones.

I started the Soft Drink Design unit one day in early October when my second graders returned from playing outside after lunch. They were all thirsty and wanted drinks of water, and so I asked what else they would like to have to quench their thirst. As they suggested different drinks, I listed them on the board and then asked whether they noticed

*Edited by USMES staff

anything about the list. When one boy noted that some drinks were juices and others tonics and that some were made from mixes and others from plain syrups, we sorted the drinks into these four categories. (See Figure C1-1 for one student's copy of our drink categories.)

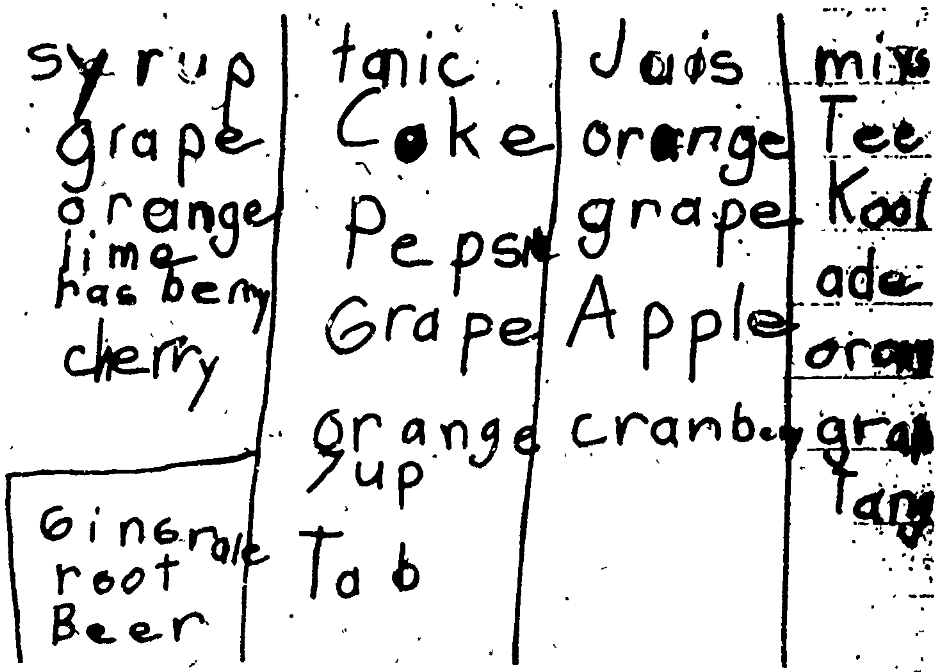

Figure C1-1

During our discussion the children agreed they would like something to drink for (1) Wednesday, a half-day when they have a morning snack, (2) after lunch, and (3) after recess. Since they had pointed out that everyone liked a different drink, I asked how we could satisfy all the people in our class. The children suggested the following solutions to this problem:

1. Mix something at home and bring it in.
2. Bring in whatever you want and mix it at school.
3. Agree on one drink, but it must be what everyone likes.

Before choosing one of the three options, the class discussed voting procedures. The children favored having each person stand up to vote rather than only raising a hand. They also agreed on these other rules:

- No one can vote twice.
- Use numbers, instead of tally marks, to indicate total votes.
- Teacher must vote.

When the voting began, however, the plan seemed too complicated. The child counting votes and the other students could not agree on how many people had stood up to vote for each choice. One student quickly solved this difficulty by giving me explicit directions for drawing a box and labeling headings. The voting went more smoothly the second time when we all individually tallied our choices in the box on the board, and there was no argument about numbers.

#1	#2	#3
Home	School	Agree
ll	~~llll~~ ~~llll~~ ~~llll~~ lll	l
2	18	1

We then added the total votes for each choice and agreed that since there were twenty-one votes cast, each of the twenty-one people in class had voted one time. Bringing ingredients to mix at school was definitely the most popular plan of action.

For the next session the students brought in drink mixes, and everyone worked individually to make his/her own drink. Some children followed the package direction for mixing and others didn't. Only one group used a teaspoon to measure the mix into the cups; the other groups just poured in a bit. Instead of only observing the children, I joined in the mixing activity and made my own drink using ingredients I had brought to class.

After we had tasted our drinks, we sat together to discuss what had happened. Although the children had enjoyed the mixing, they realized that we could improve our methods. They suggested the following changes for our next session:

1. We couldn't make the same drinks again because we couldn't remember the ingredients. We should write down our recipes.

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2. We should get into groups and make about four drinks.
3. Each group should be responsible for bringing their own ingredients and utensils. (One student sternly warned his classmates, "If you don't remember, you can't mix up your drinks. So remember!")
4. Start bringing in everything right away.
5. Bring in other things besides mixes, such as tonic, lemon juice, apple juice, tea, sugar.

The children were eager to mix again and eager to improve their operations.

At the end of this lesson one boy commented, "I betcha we're learning something while we're doing this, but it's fun, too."

When I asked what he thought he was learning, he replied, "About recipes, ingredients, and it's good to write things down. You have to remember to bring things in and to clean up after yourself."

The children seemed to remember many of their recommendations when we mixed drinks again. The class divided into four groups of approximately five members each. As they mixed drinks, all groups except one measured ingredients and recorded recipes. One member of the group that had no recipe accidentally knocked over their drink. Because they couldn't remember their special formula, they had to start mixing again from the beginning.

When all the drinks had been mixed, I followed the children's suggestion to draw a chart on the board for recording all the "Yes, I like it" responses about the tastes of the drinks. The results of our informal survey are shown below:

Kool-Aid	16	Tutti-Fruitti	10
Sweet Group	16	ZaRex Group	8

According to the children, the reasons why the Kool-Aid and sweet drinks were popular and why people buy certain soft drinks depended on three factors: (1) taste or flavor, (2) color, and (3) amount of sweetness or sourness. They agreed that before they could make a drink that would be liked by most of the class, we would have to find out how everyone felt about these three factors. At the suggestion of one student, the children decided to make a class survey.

name ____________________

Please circle your answer

1 Do you like sweet drinks? yes No
2 Do you like very sweet drinks? yes no
3 Do you like sour drinks? yes no
4 Do you like watery drinks? yes no
5 What flavor do you like? lime Orange
lemon pepsi
lemon and lime Coke
grape Coffee
apple tea
Cherry Strawberry
Root Beer Ginger Ale
tab
6 How much do you want to spend on your drink? ____
7 Do you like a syrup drink? yes No
8 What color do you like? ____
9 Do you like a fruit drink? yes No
10 Do you like a salty drink? yes No
11 Do you like a bitter taste like a coffee taste? yes No
12 Do you like some of your drinks cold? yes No
13 Do you like some of your drinks warm? yes No
14 Do you like some of your drinks hot? yes No

Figure C1-2

The next session was spent devising the questionnaire. The children first considered what factors influenced their decisions to buy certain drinks, and then they related their reasons to questions. I was rather surprised that second graders could themselves come up with so many factors that affected drink preferences. They eventually chose fourteen questions and decided how they would record their answers (mostly by circling yes or no). Two girls volunteered to copy the questionnaire on ditto paper so we could make copies for everyone (see Figure C1-2).

Since the children wanted to carry out all the plans for their survey, I agreed to let them make the ditto copies. At our next meeting we all went to the office where I conducted a session on how to use the ditto machine: location, use, safety, cleaning up. The copies were quickly made and ready to be filled out next time.

The children answered the survey questions and helped each other with reading problems. With all the surveys marked, the class, although eager to know the results, seemed at a loss about what to do with all the answers. I refocused their attention on our challenge, reminding the children that we were trying to figure out how to make one drink that everyone in class would like.

The reminder seemed to provide the needed stimulus to start the children's thinking. After one child said we should "check over the papers and make boxes on the board and add them up," the class gave me directions for drawing a chart on the board. We worked with one question at a time. As one student read the answer from each survey sheet, another student tallied the responses at the board. The results for the first four questions are shown below:

QUESTION #	ANSWERS		MOST PEOPLE LIKE	OUR DRINKS WILL NEED
	YES	NO		
1. Do you like sweet drinks?	𝍸 𝍸 |||| (14)	𝍸 || (7)	sweet drinks	sugar
	YES	NO		
2. Do you like very sweet drinks?	𝍸 ||| (8)	𝍸 |||| (9)	do not like very sweet drinks	just a little sugar

QUESTION #	ANSWERS	MOST PEOPLE LIKE	OUR DRINKS WILL NEED
3. Do you like sour drinks?	YES: 𝍸 I (6) NO: 𝍸 𝍸 II (12)	do not like sour drinks	sugar
4. Do you like watery drinks?	YES: 𝍸 I (6) NO: 𝍸 𝍸 IIII (14)	do not like watery drinks	not too much water

As each question was tallied, we discussed the significance of the vote and filled in the last two columns. For example, on the first question--"Do you like sweet drinks?" --there were fourteen yes votes and seven no votes. I suggested, "Let's review what this information means. Do most people like sweet drinks or not like sweet drinks?"

"Like them," answered the students.

"Will we need sugar or not sugar?" I asked.

"Sugar," they chorused.

The children had taken it for granted that everyone would answer all the survey questions, but they quickly realized that their directions had not been clear. They eventually decided to ignore answers that were not circled or that had two responses circled. The class was, therefore, unable to check the accuracy of their tallying because the total number of answers for different questions varied. Although they felt very frustrated, the children chose to accept these results rather than to redo the survey.

I was very pleased when the children themselves were able to solve problems they encountered in tallying. For example, on question six, which required a fill-in-the-blank answer, the children devised the following chart and drew it on the board:

6. How much do you want to spend on your drink?

10¢	IIIII	5
1/¢	II	2
15¢	II	2
5¢	III	3
25¢	III	3
$1.00	I	1
50¢	I	1

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Because the children's interest was so high, their attention span was longer than usual. We completed the tallying in two periods and then talked about how we could improve the questionnaire if we were to do it again. They made the following recommendations:

1. Make writing bigger.
2. Make it neater.
3. Use lines on the paper so it's easier to read. (Many of the students had to use rulers to line up the questions and answers.)
4. Tell everyone to answer *all* the questions.
5. People who circled two answers could come back and choose one.
6. Those who didn't answer questions wouldn't have surveys tallied.
7. Putting names on papers had been useless.

With the results tallied and our chart completed, we next analyzed the data. The children agreed that, according to the survey, a great drink for snack time should have the following factors:

1. some sugar
2. not too much water
3. grape, cherry, or lemon-lime flavor
4. purple color
5. no salt
6. no bitter (coffee) taste
7. ice or refrigeration
8. either syrup or non-syrup drinks (Both choices had received eleven votes.)

In the next session students worked in four groups to mix drinks from ingredients they had brought from home (grape, cherry, and lemon-lime mixes and syrups, and sugar). Again we had many of the same problems we had encountered in the first mixing session. Many children forgot to bring ingredients, not all groups wrote down their recipes, and in some groups a few children did all the work.

At the end of the period I gathered the children to discuss why we were mixing drinks and what our responsibilities were. The children realized that using any one of three different flavors as well as a choice of syrup or mix was confusing. It would be better, they thought, if everyone used only dry mix or syrup and only one flavor at a time. We agreed to begin with a grape syrup drink.

The next mixing lesson went much better. The children divided the work among themselves so that everyone did something, and this time all the groups remembered to record recipes. In each group one student assembled the ingredients, two or three students mixed the drink, and one student wrote down the recipe. One student's copy of the following recipe is shown in Figure C1-3:

4 teaspoons syrup (grape flavor)
4½ teaspoons water
Stir. Then put it in the refrigerator.

Donnadera

4 tea spoons of suzup
4 and a half tea spoons
of water and stirr then put
it in the fizeder

Figure C1-3

The next day we were eager to taste the four drinks at snack time, but, unfortunately, one group had forgotten to refrigerate their drink. (Rather than using ice, the students had chosen to chill their drinks in a school refrigerator.) When the children saw dust floating on top of the drink, they decided that we wouldn't drink it. It might contain germs, they feared, that wouldn't have lived under refrigeration. They agreed that in the future they would put covers on all drinks to prevent impurities from spoiling their work.

So that everyone could sample the three drinks, the children decided to do a "line up test." They put the drinks on a table, and as each person tasted all three and chose a favorite, one student recorded a preference tally at the board. The drink with the most votes was the best "cold, purple, grape, sugar, syrup" drink.

Our drink mixing, temporarily interrupted by holidays, resumed in January. Over the next several months the children systematically experimented with the three favorite choices from their survey--grape, cherry, lemon-lime--one week mixing one flavor from a syrup and the next week mixing the same flavor from a dry mix. We refrigerated the drinks after each mixing session and then enjoyed them at snack time the following day. Whenever we mixed, the children worked in four groups at tables covered with newspapers. On each group table were spoons, bowls, cups, sugar, mixes, and water. All extra ingredients were placed in a central spot so that everyone could get to them.

As they gained more experience, the children worked better together, sharing, organizing, improving their procedures, and remembering to bring in ingredients. It took less time for them to set up the mixing tables and to start work, and they cleaned up immediately, without reminders from me, when all the groups had finished. One of the most pleasing outcomes of all their mixing was a carry-over of their independence and organization to other subject areas.

Our mixing sessions were not without problems, however, but someone usually seemed to find a solution that worked. When we had a shortage of measuring cups, some groups placed rulers inside cups and marked off inches. Thus, they were able to measure so many "inches" of ingredients. (See one group's recipe in Figure C1-4.) At a later session the children had such small amounts of cherry mix that they could use neither measuring cups nor inches. They decided to use small (coffee) spoons and large spoons.

Figure C1-4

Kathleen
5cups of water
one haf of a pakage rasberry KoolAid
one tee spoon of shuger
one inch of cherry miks

One day one of the students noticed that a package had "ozs." written on it. When he found out the meaning of this abbreviation, he realized that it identified the package size. This new-found knowledge delighted his classmates who began to specify package sizes in their recipes. Another group noticed that when one package of lemon-lime powder was mixed with water, it made a quart, so they used that as a measurement.

Other improvements in recording recipes were also made. One group finally remembered to include which measuring utensil they had used. In their first recipes they had included directions such as "½ ZaRex."

"One-half what?" I asked, and they wrote "½ c. ZaRex." Gradually my questions were no longer needed. The various groups also realized that if they modified their recipes by adding more of an ingredient already included, they didn't have to write down each addition separately but could increase the original amount written down.

One session that had been scheduled for mixing turned into an unplanned art period. Several children who had finished other classwork began drawing pictures and writing stories about our Soft Drink Design investigations. This idea started with a few students and quickly spread to the entire class. The drawings showed groups of children mixing in class, mixing "experiments" they had tried at home, and pictures of the utensils we had used. In their stories many children mentioned how happy they were to be mixing, the different flavors they had used, cleaning up after mixing, and our discussions.

The following story was written by a boy who normally did not like to write stories:

> "This boy is mixing. He is mixing cherry koolade and after he is done he puts his stuff away. And he goes out and when the koolade is cold he drinks it."

We taped the pictures and stories on a class bulletin board but our art work had not ended. About ten students were so enthusiastic that they asked to stay after school to make a mural showing their Soft Drink Design work. I agreed that it was a good idea, and the next day many other students spent their free activity time helping to complete a three-foot by eight-foot mural. Besides pictures of boys and girls mixing with bowls, glasses, cups, and measuring cups and spoons, the children also added their comments, such as the following:

> "They're mixing a soft drink--it's cherry."
> "They're standing behind a desk and mixing."
> "They feel happy."
> "I like doing this--it's fun."

The children taped the mural outside our classroom and added a heading, "Soft Drinks," so that other people would "know what we're doing."

Competition to make the "best" drink was not a major concern of the children as they mixed grape, cherry, and lemon-lime drinks. Each group was more involved in making a drink they liked rather than one the entire class would enjoy. After mixing all three drink flavors from both powder and syrup forms, the children did decide to choose one favorite drink. Their discussion of how the selection would be made continued for a while before they agreed to vote first on whether they preferred syrup or dry mixes. One child designed a chart on the board and our votes were tallied in two boxes like the following:

SYRUP

YES	NO
卌 卌 |	卌 |

DRY MIX

YES	NO
卌 |	卌 卌 |

The children noticed that the votes for syrup (eleven yes, six no) were the exact reverse of the votes for the dry mix (six yes, eleven no). Therefore, they reasoned, the votes must be correct. One girl also pointed out that each category had seventeen votes and seventeen people were present.

Votes were also tallied at the board for the three flavors:

cherry 卌 ||
lemon-lime 卌
grape 卌

The children again totaled the votes and were pleased that the number was again seventeen.

Since cherry syrup drinks were the most popular, I distributed to the four groups their recipes for these drinks, and I reminded everyone of our challenge to make a drink that all of us would enjoy. One student asked whether anyone could bring in additional ingredients to use in their cherry syrup drinks. The other children realized that this would alter their recipes, but they agreed with his suggestion and decided to bring in ingredients such as cinnamon, lemons, instant iced tea mix, and soda water.

Instead of adding new ingredients to their old recipes, the children decided on mixing day to make entirely new recipes and then compare the first and second drinks. Since

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no one had been able to find cherry syrup, they used cherry tonic instead, reasoning that because the tonic had originally been made from a syrup, it would be a good substitute. The class worked in three groups and the children were more adventurous in their experimentation with ingredients. One group added lemon-lime syrup to their drink while another group used strawberry Kool-Aid, honey, iced tea mix, and cinnamon. The third group added grape Kool-Aid, honey, and cinnamon.

The shortage of cherry syrup also affected our mixing session the following week when the children planned to reproduce their original cherry syrup drinks. They had brought in raspberry syrup, the closest flavor to cherry, and wanted to try to get cherry syrup for next week. During this session the groups experimented with several new flavors. One group found a difference in taste between white and brown sugar and decided to use brown sugar. Another group, divided over whether or not to add honey to their drink, compromised by adding only a small amount. A third group wanted to include flour, but the children were afraid it would turn lumpy and spoil their drink. They experimented by adding flour to just a small amount of drink. It did indeed turn lumpy and flour was omitted from the ingredients.

We soon recognized that our Soft Drink Design work would be indefinitely delayed if we continued to wait for cherry syrup. One girl led a class discussion of how we could solve this problem. Since syrup was more popular, should we choose another flavor and continue to use syrup, or should we stay with cherry flavor and use a dry mix? The students first tackled the problem of syrup versus dry mix. The sixteen to two vote showed strong support for syrup. Next they voted between the two runner-up flavors, grape and lemon-lime. Grape flavor won, eleven votes to seven. Everyone agreed to work in four groups to make grape syrup drinks and then vote to choose the favorite one.

At this session we also started discussing wha- companies do when they make a soft drink. The class thought that companies must make enough of the drink to sell, always using the same ingredients as before. To sell a drink, a company could set up a drink stand or sell it in a store using plastic or glass bottles, cans, packages of ingredients, or cups. They realized that cups were not good containers for stores to use because the drink might get hot, sour, or dusty. They thought that a company must also decide on the cost of ingredients and its profit.

Several students did not know what profit was, and so one boy explained that it was the money left over after paying for the ingredients. He described his experiences selling Kool-Aid at a stand the past summer, noting that his selling didn't really count because his mother had paid for the ingredients. Nevertheless, he would pretend he had paid for them to show everyone how to find profit. He guessed at the cost of his ingredients:

1 package Kool-Aid	35¢
20 cups	50¢
some water	? (in parents' water bill)
20 cups of drink =	85¢

He said he sold twenty drinks at 5¢ a cup, and we came up with the following way to figure his total income:

5¢	1 cup
5¢	2 cups
5¢	3 cups
5¢	4 cups
+ 5¢	5 cups
25¢ made =	5 cups (sold)
50¢	= 10 cups
75¢	= 15 cups
$1.00	= 20 cups

The students then figured out he had to pay his grocery bill of 85¢ for ingredients, and what he had left would be his (profit):

$1.00	made
- .85	cost of ingredients
$ .15	profit on 20 drinks

The idea to expand our Soft Drink Design challenge from making only a snack drink to selling it to other people originated during this session. The children were excited over the prospect of figuring profit on the class drink.

As they had planned, the children spent the next session mixing grape drinks in groups. Once the four drinks were mixed and the recipes recorded, we discussed possible ways to vote for the best one.

One boy suggested, "Everybody can taste the drinks and then we can pick out the one we like the best. We can put names on them, and then people can put a mark on the board next to the one they vote for. Then we can count how many

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and see which one everyone likes best."

Other children felt the ballot should be more secret. We finally agreed that everyone would whisper his/her choice to one person and that person would record all the votes. The winning recipe was the most simple one:

1 cup grape ZaRex
2/3 cup club soda
3 cups water

Once the favorite drink was chosen, we had to decide how to proceed. Since our lesson on profit, the children were enthusiastic about selling their drink to other classes. They came up with three suggestions and then divided into groups accordingly:

1. working on advertising for the grape drink*
2. mixing large quantities of the recipe and bottling it
3. making a drink stand

Group work continued for the entire month of April and part of May. I noticed that the children seemed to regard USMES as an all-day subject. When they finished their classroom assignments, they would take off on their own to work on their particular group activities. Motivated by their own interest, they would get their groups together for meetings, organize the work, and divide the labor so that everyone participated. We held frequent class meetings so that everyone was aware of the progress of other groups. The activities of each of the three groups are described in the following paragraphs.

The Mixing Group first practiced making our recipe to be sure they could duplicate it, and then they began scrounging and cleaning quart bottles. The children had decided to bottle their drink because (1) it was healthy (prevented dust from getting into drink); (2) it was safe (drink wouldn't spill easily); and (3) it was speedy for distribution (just deliver bottle and sell). The group made a list of ingredients they would need to make a large quantity of

*Should children have time to conduct comprehensive investigations on their advertising campaign, teachers might refer to the challenge in the Advertising Teacher Resource Book. --ED.

drink, and I agreed to purchase the supplies and to be reimbursed later from the profits.

At one point I had to remind the Mixing Group about the importance of accurately measuring ingredients each time they made a bottle of drink. With the help of the Advertising Group, they also decorated the bottles with colorful labels.

The Advertising Group decided to bring in magazines, paint, and paper and to ask the art teacher for odds and ends. They initially spent their time thinking up slogans and making posters, gradually becoming more aware of the importance of letter size and readability. By tallying the number of classrooms in our building, they figured out how many posters to make. The children also considered, but rejected, advertising gimmicks, such as offering a free cookie with every drink. To prepare for selling their drink in other classrooms, several children composed and rehearsed the following announcement:

> "Come to our Soft Drink Sale Friday, May 10th at 10:00 a.m. We will be selling this great soft drink! (Show bottle.) It will be 50¢ a bottle. You can all chip in and buy a bottle for the class to share. It's delicious."

Once some of the drink had been bottled, the Advertising Group devised labels for the bottles. Of the four designs with the names, "Grape Special," "Super Snake," "Silly Willie," and "Super Grape," the latter received the most class votes.

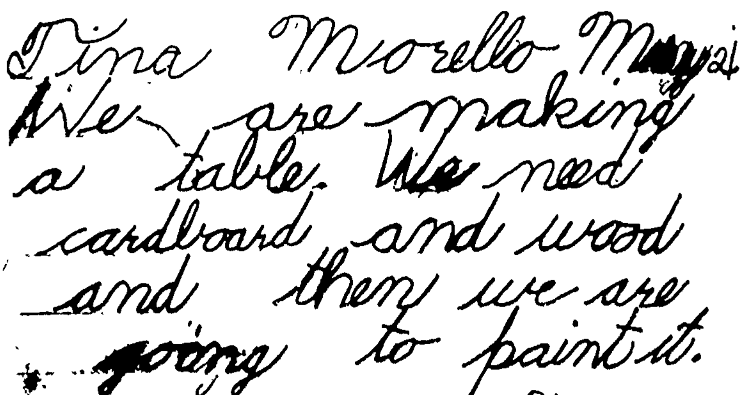
The winning artist then made a copy of his label on a ditto master so that the labels could be reproduced in quantity, colored, and cut out. When they tried to put the labels on the bottles, the children discovered that their idea to use transparent tape wouldn't work; it didn't stick to the bottles when they became moist in the refrigerator. Fortunately, the school paste worked well on wet or dry bottles.

The Drink Stand Group started out by drawing designs of possible stands and making verbal and written reports on their ideas. After some discussion and looking through books for new ideas, the children improved their original designs and decided to vote within the group for the best one. As they discussed the balloting, they realized that it wasn't a popularity contest and agreed that a person could vote for his/her own design if that one was best. A drink stand with a design similar to the one below was selected.

"We are going to put aluminum foil on the top and a window and we are going to have a door."
Jay

When the Drink Stand Group began work in the Design Lab, they found that their stand would require more glue than was available. Therefore, they decided to modify their design and make a simple table with interlocking legs and a wooden table top. Everyone took turns with the saber saw. One student's description of their work is shown in Figure C1-5.

Figure C1-5



During our class meetings for group reports the children made constructive suggestions to members of other groups:

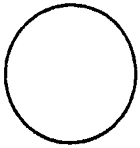
> "I think your letters should be neater and larger."
> "How about putting a sign on your stand that says, 'Soft Drinks for Sale.'"
> "You'll need more ingredients to make enough to sell to a lot of people."
> "Use a funnel when you pour it into bottles."

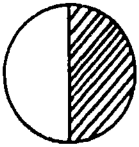
The children made good use of the suggestions and improved their own work. They also made recommendations to others in their groups for making needed changes.

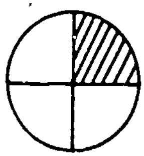
We also worked together as a class to do a cost analysis and to determine a sales price for our drink. First we worked on the price of club soda. We knew that one bottle of our drink needed one-half cup or four ounces of club soda. We also knew that there were thirty-two ounces in a bottle of club soda. Using this information, we made the following calculations on the board:

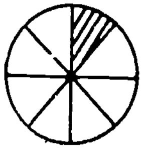
1 bottle of Super Grape uses 4 ounces of club soda
2 bottles of Super Grape uses 8 ounces of club soda
4 bottles of Super Grape uses 16 ounces of club soda
8 bottles of Super Grape uses 32 ounces of club soda

Thus, we could use one bottle of club soda to make eight bottles of Super Grape. Since club soda cost 40¢ per bottle, we just had to divide 40¢ by eight. To do this, I drew the following diagrams on the board:

1.  40¢ if we use whole bottle

2.  20¢ if we use ½ bottle

3.  10¢ if we use ¼ bottle

4.  5¢ if we use 1/8 bottle

We concluded that club soda would cost us 5¢ for each bottle of our drink.

Next we analyzed the cost of ZaRex per bottle of Super Grape. We had compared the price of ZaRex at various local stores and found the best buy was 45¢ a bottle. Since we needed one-half bottle of ZaRex for each bottle of our drink, we calculated that we would be spending 23¢ on ZaRex. Adding 23¢ plus 5¢ we came up with a cost of 28¢ per bottle of Super Grape.

With the cost settled, the children debated the sale price. I suggested, "Let's decide on a price."

"Thirty-eight cents," offered one child.

Another student reasoned aloud, "We're trying to make a profit. We're the ones who are selling it."

"We buy the stuff, we mix it, we sell it," said a third student, "and then we make a profit if there's enough."

"Twenty-nine cents."

I reminded the class, "You have to pay me $1.24 for the ingredients."

"How about fifty-nine cents?" asked a student.

"Fifty cents," suggested another one.

When the children voted, sixteen out of twenty-one favored a sales price of fifty cents. Next we figured out the amount of profit per bottle:

> Teacher: It's going to cost you twenty-six cents and they're going to pay fifty cents. Does anyone have any idea how much profit you're going to make?...How much is twenty-six to thirty-six?
>
> Students: Ten.
>
> Teacher: How much is thirty-six to forty-six?
>
> Students: Ten.

Teacher: That makes twenty. Forty-six to fifty?
Students: Four.
Teacher: Twenty and the other four makes...
Students: Twenty-four.
Teacher: Twenty-four cents profit for every bottle.

To my amazement, we had spent an hour and a half making a cost analysis and deciding on a sales price.

Three days before our first sale date, two children from the Advertising Group went to another second-grade class. They put up posters, showed a bottle of Super Grape, and gave a pep talk encouraging the children to contribute five cents each to buy several bottles of our drink for their class.

When two bottles were sold the first week, we decided to continue this routine of advertising on Wednesday and delivering the drinks by hand on Friday. Using this plan meant that the drink stand was no longer necessary, but we decided that the table could be used for many other things in our classroom.

Spurred on by our initial success, the Mixing Group made the following calculations in anticipation of the second week's sales:

50¢	=	1 bottle
\$1.00	=	2 bottles
\$1.50	=	3 bottles
\$2.00	=	4 bottles
\$2.50	=	5 bottles

\$1.00	sales so far
+ \$2.50	sales projected for Friday
\$3.50	

\$3.50	total projected sales
- \$1.24	teacher's bill for ingredients
\$2.26	

Their prediction turned out to be a little high--three bottles were sold the second week. Nevertheless, sales were improving, and the group busily mixed four more bottles to prepare for a further escalation in sales.

Drink sales continued for another month with each group doing its share of the work. When the posters began to look shabby, the Advertising Group made new ones and the group members took turns giving their pep talk in different rooms.

The Mixing Group worked hard to keep on top of increasing sales. They devised the following chart to tally each week's order:

initial of teachers	F	N	L	K	W	M	G	E
number of bottles	2	2	1	?	2	1	1	2

After starting their construction activities in the Design Lab, the Drink Stand Group finished making their table in the classroom, using tools borrowed from the lab. The children had originally planned for a waist-high table, but when they had it assembled, they discovered that it was too tall and too wide for easy reach.* Therefore, they spent one session cutting the top in half and sawing several inches off the legs. Their final design was a wooden table top glued onto three rectangular Tri-Wall legs. The three legs each had two slits in them with two Tri-Wall boards inserted lengthwise into the slits for support.

At the end of six weeks of sales, the popularity of Super Grape had soared. During one busy week twelve bottles were sold to students and faculty in the school! After our final week of sales, I helped the class total my weekly bills for ingredients, and we subtracted them from our total income. Our profit came to $7.04.

Discussions of profit had an interesting carry-over to a reading lesson. The children applied the concept of profit to a story about a boy who purchased dough from a baker and then sold it for more money than he had paid for it. This story was not intended to pose a math problem, but the children quickly related it to what they had learned from Soft Drink Design.

The class agreed that our own profits from the drink sales should be shared, spending half the money for ourselves and half for someone else who needed it. Buying a

*The children might discuss what measurements are needed to determine the best height and width for a classroom table. They could then collect the data and find the median measurement(s). See Designing for Human Proportions unit.--ED.

plant for the nursing home near our school was chosen as a good way to use our money to help other people. The children were excited about their plan and wanted to explain how they had earned money to buy the plant. To accompany their gift, a class booklet was made using new stories and drawings of their work on Soft Drink Design.

We walked together to a local florist to select an appropriate plant, and later we visited the nursing home. The director gave us a tour of the home and introduced us to the people. One of the boys made a speech and presented the plant and the booklet.

On another day we took a third short field trip to spend the remainder of our profit. We bought ice cream cones for everyone in class.

School was quickly nearing an end, and we spent our final day on Soft Drink Design evaluating what we had learned. Some of the children's remarks are listed below:

- how to measure (using a ruler, measuring cups, quarts, etc.)
- how to vote and how to count the votes
- how to break up the work
- how to share
- how to make a drink kids will like
- how to make a new recipe; how to add new ingredients in a drink--how to experiment
- how to figure out how much to sell a drink for
- how to advertise; how to be a good salesman; how to run a sale
- how to guess how many bottles might be needed by a class
- when you grow up and want to sell something you'll know what a profit is
- how to count our money
- how a small factory would run a business
- how to use tools, glue, paint; how to fix something
- how to draw a picture and write a story about what we have been doing

2. LOG ON SOFT DRINK DESIGN

by Janice Turner*
Whitehead School, Grade 5
Athens, Georgia
(October 23-December 20, 1974)

ABSTRACT

While this fifth-grade math-science class was discussing a usual need for more drinks at school parties, the children decided to make their own class drink. After the first mixing session, the students, who worked in six groups, evaluated their work and made recommendations for improving their procedures. They assigned responsibilities to each group member, standardized their measurements, carefully recorded recipes, and devised a secret ballot for their taste test to choose the most popular drink. The class soon realized that part of their challenge, to produce a drink at a reasonably low cost, had not been met. Consequently, the students compared costs of ingredients from different stores, and after skill sessions on liquid measures and measurement conversion, they computed the cost per ounce of ingredient and per quart recipe for each group's drink. Data for cost and popularity were depicted on line graphs and compared. The children next debated whether to choose the class drink by popularity or by cost, finally agreeing to make the cheaper of the two most popular drinks. Next they calculated the quantity of drink needed to serve ninety-six children at the fifth-grade Christmas party. After increasing their recipe, the children correlated the amounts of ingredients needed to specific sizes of bottles, packages, and jars for a shopping list. On the day of the party the class mixed and served six gallons of their drink.

I introduced the Soft Drink Design challenge to my fifth-grade math-science group during a class discussion of school parties. I mentioned that although there was usually a good supply of candy, cupcakes, and other things to eat, we rarely seemed to have enough drinks. When I asked what could be done about this problem, the children mentioned bringing soft

*Edited by USMES staff

ERIC

Paula's Group (#1)
1 Table spoon of Lemon-jello spoon
2 Tablespoons of coke c
2 Table spoons of 7up c
2 Tablespoons of real lemon c
1 Tal spoon of Gingerale spoon
1/4 Tablespoon of water

Like	Don't like it	Didn't Taste it
25	1	3

Suki's Group (#4)
2T sugar c.
grape + orange cool aid half teaspoon guess
7up coke
ginger ale

Like it	Don't Like it	Didn't Taste it
22	1	5

Mark's Group (#2)
7 up
Sprite
gingerale
grapefruit

Like it	Didn't Like it
6	4

Not Tested
16

Antoinette's Group (#5)
Did not keep a recipe

Figure C2-1

drinks and Kool-Aid from home, and one student suggested bringing mixes to prepare drinks at school. After a brief discussion of drinks the students liked, I asked whether anyone had ever mixed his/her own concoction. Many students had, and they became very excited as they shared their experiences using different ingredients.

When all had had an opportunity to relate a story, I wrote the challenge--"Mix a soft drink that is popular and can be produced at a reasonably low cost"--on the board. We discussed the meaning of "popular," and the children agreed on a definition--"something that most people like." When I asked for a clarification of "most" people, they began calling out numbers: one-half, 75 per cent, 50 per cent, 98 per cent, 88 per cent, three-fourths.

"If one-half of the people like something and one-half do not, do most of the people like it?" I asked. After some debate, everyone agreed that "most" people would be more than half or more than 50 per cent.

Just before the end of this session, the thirty-one students formed groups of four, five, or six members. Each group met and first listed ingredients they would need to mix drinks and then discussed mixing procedures.

The next day the class met in the Design Lab, and we briefly reviewed the challenge before the mixing began. After initially experimenting with individual mixtures, most groups began to combine their efforts to make a group drink. Since only two groups had begun to record any form of recipe after about twenty minutes of mixing, I asked the students whether they would need to reproduce their drinks. One boy immediately placed his ruler by the one-ounce cup to measure his ingredient, and several other students followed his example.. By the end of this first mixing session, two groups had decided on some kind of measuring system, but the other four groups had only a partial system or none at all.

I also noticed that as the students experimented with different ingredients, they had polled each other for opinions about the taste of drinks they had mixed. Their surveys had been rather haphazard, however, and none represented the opinions of the entire class.

Following this session, I transferred the recipes and the survey results that had been recorded to transparencies. (See Figure C2-1 for results from four groups.) Then each group separately reported on the procedures used in devising their recipe and in conducting their survey.

After the group reports, all the children agreed that the survey results were not reliable indications of taste preferences for the class because, as they pointed out, not everyone had been questioned about each drink and the groups had asked different questions on their surveys. In some groups neither records of survey questions nor results had been kept. Most students, especially one group of girls, were very honest about their favoritism voting. They admitted that their feelings toward their classmates had influenced their opinions about the drinks they had tasted.

Since we all agreed on the need for a survey that would keep pers al feelings about other people from influencing the voting, I listed several questions about surveys for the students to consider before our next meeting:

1. Do we all need to use the same questions on our surveys?
2. What kinds of questions do we need to ask?
3. How can we conduct a survey to eliminate "friend" and "enemy" voting?
4. What kind of procedure should we use to conduct the survey?

At our next session we first tackled the problem of varying measuring methods used in recording recipes. I asked, "When you say 'cup' in the recipe, do you mean the tiny cup or the middle-sized cup?" The children decided they might standardize their measurements by using measuring cups from home or the one-ounce medicine cups available in the Design Lab.

Before class I had set out six quart jars in the room without calling the children's attention to them. When we discussed what quantity of drink each group should make so that there would be enough for everyone to taste, several students decided to find out how much liquid one of the jars would hold. Using one-ounce cups to measure water into the jars, they discovered that it took thirty-two ounces to fill a quart jar. The class decided that by serving each drink in one-ounce cups, a one-quart recipe would be just enough for our class of thirty-one children.

After our class discussions the children felt that their first mixing session had been a disaster. To avoid their previous mistakes, they decided to meet in groups to write down their plans for the second round of mixing. They also listed individual student responsibilities, such as bringing in materials and cleaning up after mixing. (See Figure C2-2 for one group's division of responsibilities.)

Paula's Group

(Clean up) Terri brought A sponge for Clean up

Paula spreads newspapers

Dawn pick's up newspapers

Susan drys table

Donna + Cristy help clean,

Figure C2-2

Later that day we met as a class to discuss the decisions made by each group and to hear suggestions for conducting a fair survey on drink preferences. One of the students said, "Make the person tasting the drink look you squarely in the eye and swear he isn't voting for a drink because it is his or a friend's." His classmates quickly disagreed, saying that this plan just wouldn't work. Other suggestions were made and also found unsatisfactory. Finally one student resolved the problem with a suggestion we all found acceptable. We would number the drinks, and no one except me would know the identity of the drink inventor.

Choosing a method for voting among the drinks involved another debate. The children agreed to have a written ballot, but they argued about whether it should be public or secret. When the class voted on which of the two methods to use, private balloting was the choice. This session ended with the students reminding each other not to forget to bring ingredients to the next class.

Spirits were high at our next session. Most of the children had remembered to bring ingredients and measuring utensils, even after a weekend break. Our previous planning session helped to eliminate quite a bit of confusion. We had decided that all mixing areas would be covered with newspapers and that each group would have a certain location for working. The groups went immediately to their prearranged locations and began mixing in great earnest.

Instead of trying to reproduce their first recipes, most groups made new ones, using the same ingredients as before, but with different quantities to make one quart of their drink. The students were careful to record their recipes, noting the exact measurements of the ingredients they added.

As each group finished their recipe, I assigned the drink a number and recorded which group had mixed it. When all the mixing was completed, everyone tasted each drink and, on a secret ballot, rated the drink good, fair, or poor. (See sample ballot in Figure C2-3.)

At our next meeting we evaluated the second mixing session. The class consensus was that this session had been smoother and that more had been accomplished than during our first attempt at mixing. The children felt this had been due to better planning.

"We planned better so we knew what we were going to do."

"We didn't argue about things."

"We worked in a hurry and cleaned up in a hurry because we knew who had certain duties."

When I asked what kinds of things they had learned, one student commented, "It's easier to work with a measuring cup."

Figure C2-3

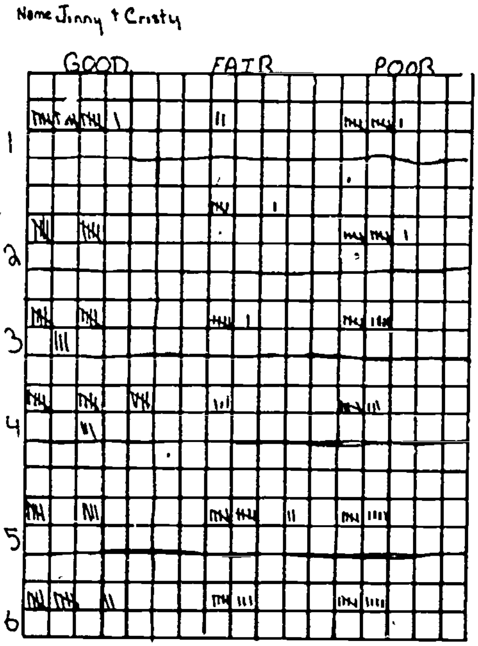


Figure C2-4

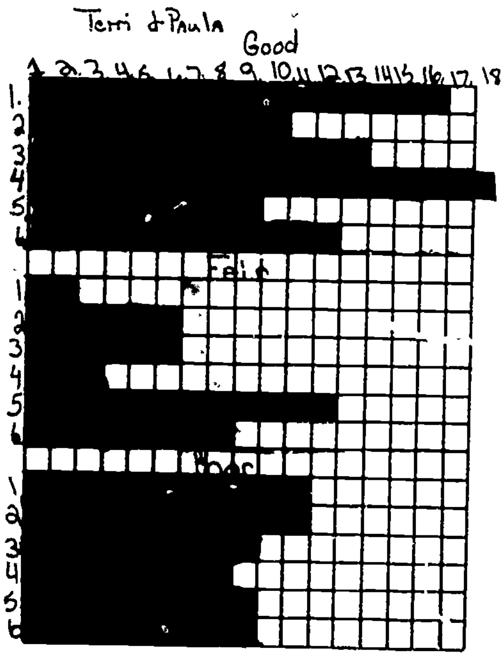


Figure C2-5

Another said, "Having a plan helps."

Then, with the children working in pairs to keep their own records of the results, we tallied the survey questions on the board. (See students' tally sheet in Figure C2-4.) Looking at the results afterwards, we discussed whether the winning drink with eighteen votes would fit the children's definition of popular. One boy went to the chalkboard and figured that twenty-eight people had voted. Since eighteen was more than half of twenty-eight, drink #4 was liked by most people in the class.*

When we refocused on our challenge, the children realized that we had completed only part of what we had set out to do; we had not yet determined whether any of the drinks could be produced at a reasonably low cost. I suggested that each group list the prices of the different ingredients in their recipe. One boy saw a difficulty, however, and said, "But we used only one cup of the big bottle of ginger ale." I admitted that we had a problem but that we would find a way to solve it.

During the next session we reviewed the outcome of the survey, and I asked the children to work in pairs to make a picture of the results. One bar graph (see Figure C2-5) and one pictograph were about the only real graphs made. I decided then that we would definitely need a skill session on graphing before we continued this exercise.

Because of holidays and other team-teaching commitments, our USMES sessions were postponed for almost three weeks. When we were able to continue with Soft Drink Design at the beginning of December, we reviewed our challenge and what we had accomplished before the interruption. Since we wanted to serve our drink at the fifth-grade party on December 20, we decided that we must have a plan.

We had selected a popular drink, the children agreed, but we still needed to make a cost analysis of the ingredients.

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*According to the students' tally sheet, drink #1 received sixteen votes. The class might discuss whether the two votes separating drink #4 and drink #1 represented a significant difference. Before making their decision, the children might also check to see whether the total number of good, fair, and poor votes for each drink was the same. (The difference in the total tallies shows clearly on the bar graphs that the children later constructed.) They could then consider the fair and poor rating for the two drinks. See footnote on following page. --ED.

Steps for Deciding on the drink For the Party:

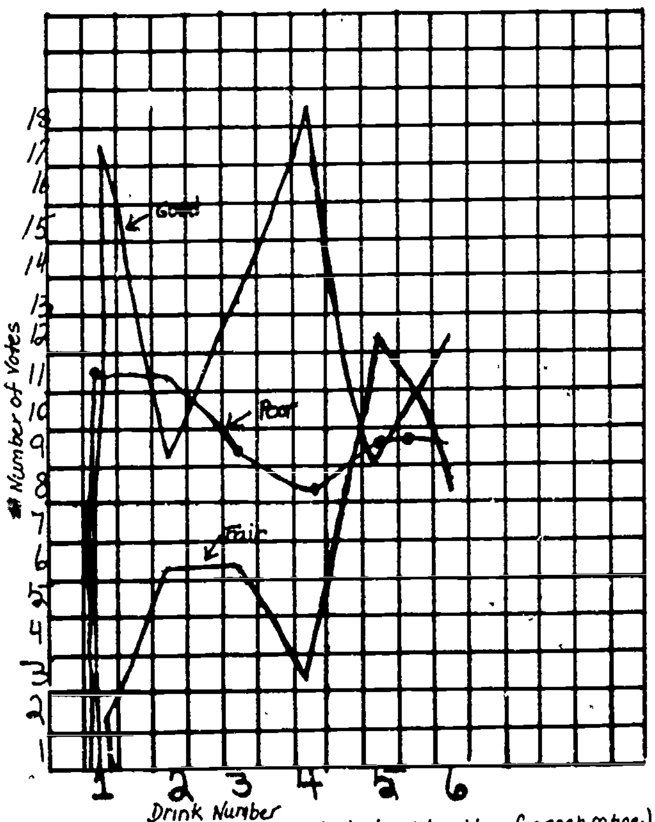
A Find the one that costs Less

1. Collect data on cost of ingredients.
3. Add costs of ALL ingredients together.
2 Study Measures.
4. Compare the costs of ALL the drinks.

B Make up A List of Duties.

C Figure out how to Make enough recipe for 2 cups per person for all 3 5th grades.

Figure C2-6



(Original graphs had a colored line for each rating.)

Figure C2-7

When one student questioned what we would do if the popular drink was also high in price, one of the boys answered, "We'll have to decide on price first or quality first."

While the children listed the steps they felt were necessary to meet their challenge, one student took notes (see Figure C2-6). Then I posed the question that one child had mentioned at a previous meeting, i.e., "How will we find the cost of one cup of an ingredient if we know the cost of the whole bottle?" I suggested that an additional step to include in our list of tasks might be a lesson in equivalent measures.

Using the overhead projector, we reviewed the list of ingredients we had used and the cost per package or per bottle. One of the children immediately pointed out a discrepancy, "That's not the right price for sugar now." We realized that the cost of sugar had risen substantially and that there might be increases in the prices of other ingredients. Our first priority, therefore, would be to recheck our price list and make any corrections. Four students offered to form a committee to collect price information that evening.

For the remainder of the session we had a skill session on making line graphs. We reviewed the drink preference survey results, I showed the children the first set of graphs they had made, and then the students made line charts of the survey results.* (See copy of one student's line chart in Figure C2-7.**)

*The students could also calculate an average score for each drink by assigning one, three, or five points to each rating according to whether it was a poor, fair, or good vote. A bar graph could then be made to show the average scores.--ED.

**Technically, the line charts drawn by the children would be more appropriately drawn as bar graphs because the distance between points on the horizontal axis has no significance. In such cases as this, when two or more sets of data are compared, a line chart may be preferable because the data can be read more easily. Children may be referred to the set of "How To" Cards, "How to Decide Whether to Make a Bar Graph Picture or a Line Graph Picture of Your Data."--ED.

The following day the Shopping Committee reported on the current ingredient prices at several stores they had visited. Noting a wide variance in the prices, the class discovered that one large supermarket had consistently lower prices for most of the items we needed. They agreed that we should shop at that supermarket and that we should use those prices to figure out the costs of our drinks.

As we began to list the prices for the ingredients in each of the six recipes, we also discovered that all the ingredients were sold in ounce measurements. When I asked how many ounces were in a cup, a half-cup, a pint, and a quart, the students realized a need for further math skills.

In this same session we then began a skill session on liquid measure. Using gallon, quart, and cup containers, we poured water from one to the other. As we determined the capacity of each container, we recorded the information on a chart on the overhead projector.

1 cup	=	8 ounces		
2 cups	=	1 pint	=	16 ounces
4 cups	=	1 quart	=	32 ounces
2 pints	=	1 quart	=	32 ounces
4 quarts	=	1 gallon	=	128 ounces

The children who had measured in teaspoons obtained measuring spoons from the cooking center and one-ounce containers from the Design Lab, and they proceeded to figure out their measurements in ounces. Then, armed with their recipes and the price list for ingredients, the students met in their groups to calculate the cost of each ingredient in their recipes.

All the groups were stuck on one calculation--if thirty-two ounces costs 44¢, how much does eight ounces cost? We tackled this problem together, and when the students understood the steps involved (first finding the cost of one ounce by dividing, then multiplying by the number of ounces in their recipes) they returned to their groups.

Another problem soon brought us back together--if five pounds of sugar cost $3.12, how much does one ounce cost? First we calculated that one pound of sugar cost about 62¢. Several students consulted a math book to find that one pound equals sixteen ounces. By converting pounds to ounces, we found that one ounce of sugar cost about 4¢.*

*The children might discuss the difference between ounces of volume (1 cup = 8 fluid ounces) and ounces of weight (1 lb. = 16 oz.).--ED.

ERIC

Suki's Group Janne

11¢ 1½ ounce of Strawberry jello
.06 1½ ounce of grape Lipton drink .06
11¢ 1½ ounce of Black cherry jello
.25 12oz of Doctor Peper 12oz
.05 1 ounce of Brown sugar
.03 2oz can of Gingerale
ounce of canada dry

	2
3oz = 22¢	.25
1½ oz = 11	.11
	.11
16oz = 69¢	.06
1/16 = 4 5/16 = .05¢	.05
	.03
32oz = 44	.61 - quart
2oz = 2 2/3 = .03	

1 person = 1 cup 90 people
1 qt = 4
22½ quarts

Figure C2-8

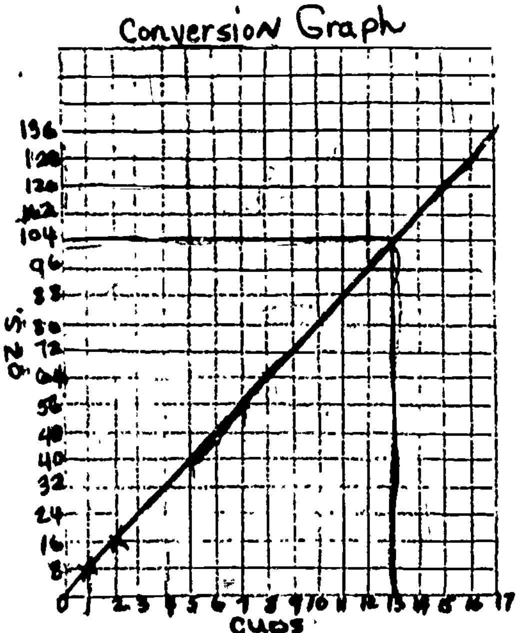


Figure C2-9

With these two difficulties resolved, the groups continued working on the cost analysis of their recipes. During this period some groups were able to complete their lists, and they handed in their recipes with the measurements converted to ounces, the ingredients priced, and the total cost calculated for making one quart of their drink. (See one group's calculations in Figure C2-8.)

As this session ended, the children again mentioned their concern about which drink we would use at the party, the one that won the taste test or the one that was most inexpensive. One girl suggested that we make a cost graph for the six recipes. Then we could compare the graphs on popularity and on cost when we made our decision. This idea received everyone's approval.

Because some of the groups were still working on converting their measurements to ounces and figuring out the cost of each ingredient, we again reviewed the liquid measurement skill session on the following day. We also looked at the "How To" Cards, "How to Make a Conversion Graph to Use in Changing Measurements from One Unit to Another Unit." Then, using the overhead projector, we constructed a conversion chart of cups to ounces (see Figure C2-9) and converted some of the recipes.

Two groups were having a great deal of difficulty computing the costs of ingredients, and so the class worked together to list the operations to perform. When we completed the cost analysis, it was apparent that we needed additional work on division with two-digit divisors and on fractions. By the end of this session, however, all six groups had computed the cost for one quart of the drinks they had invented.

At the next meeting we compared the steps we had taken in the past several sessions with our list of needed tasks. Now we were ready to compare the costs of the six drinks. I distributed graph paper, and the students worked in pairs to make line charts containing the following price information*:

#1 Paula's group	$ .73
#2 Steven's group	.38
#3 Keith's group	.44
#4 Suki's group	.61
#5 Antoinette's group	1.82
#6 Wayne's group	.92

*In this case, a bar graph would be easier to read and actually more appropriate since the distance between points has no significance. See footnote for Figure C2-7. —ED.

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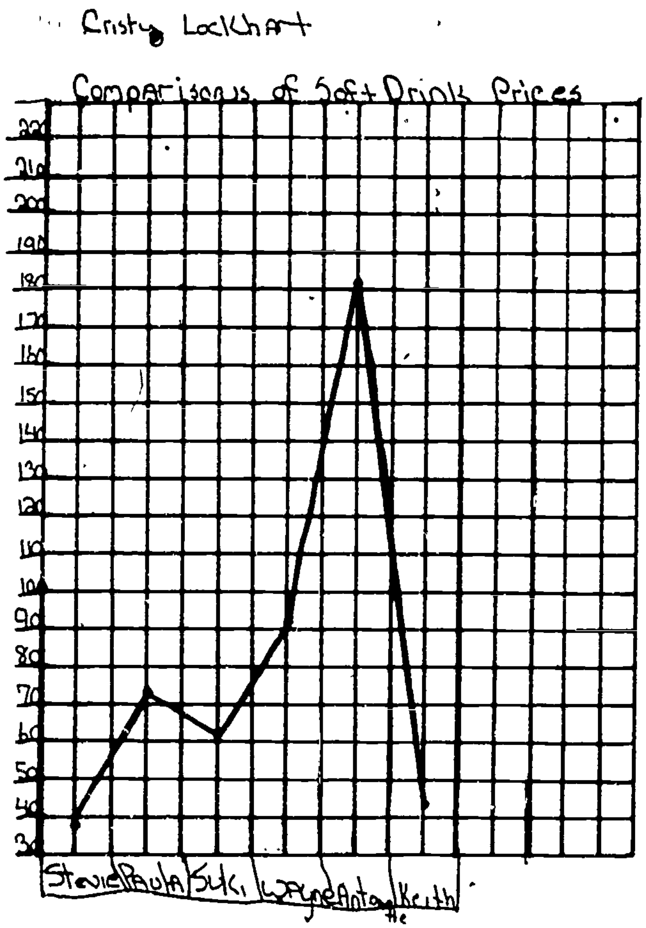

Figure C2-10

When the children finished their graphs (see one copy in Figure C2-10), we had to decide between the most popular drink and the least expensive drink. This decision caused quite an uproar, but after much discussion the students decided on the following three alternatives:

1. Let's use the top two popular drinks.
2. Let's start over again. (They really loved the mixing.)
3. Let's just choose the cheapest drink.

There was still no class consensus, however. After a while the children repeated the challenge and realized that none of their options was really appropriate. A compromise was finally reached. The class agreed to choose between the two top drinks from the popularity survey. Since the favorite of the two drinks was also cheaper, it became the choice for our party.

After again referring to our list of things to do, we began our next task, determining the quantity of our drink to make for the ninety-six fifth graders who would attend the party. Originally, we had planned to serve the drink only to our class. However, because the Christmas party was held by homerooms and my math-science group was not necessarily my homeroom, we invited other homerooms to use our drink at their party. (This had been my oversight, and had we realized the situation earlier, we would have conducted a drink preference survey of all the fifth graders.)

Rather than calculating servings for 96 students, the children decided to work with 100 because it would be easier. Two paper cups or eight ounces of drink per person would be an adequate amount, they agreed. Then, working in groups of two or three members, the children began to figure the quantity of drink needed for each of the three classes. Two groups completed the task without assistance.

When the other groups were unable to make much progress, we again used the overhead projector to work on the problem together. The children began by multiplying 8 x 100 to find the total ounces needed. They imagined pouring 800 ounces into quart jars, and we acted out the process using a quart jar to find out how many times 800 ounces of water would fill it. Each time we poured, we subtracted 32 ounces from the 800 ounces until we had no water left. Afterwards, I asked the students what we had done, and they replied, "We have divided up the water." Suddenly they "saw" the concept they had been using: division can be accomplished by repeated subtraction.

Mrs. Turner   Suki's Drink Ingredients
increased 8 Times for our Room Party.

4 sm pks	12 oz.	strawberry jello
1 jar	12 oz.	lipton grape drink
4 sm pks	12 oz.	Black Cherry jello
3 bottles	96 oz.	Cola Drink
1 bottle	16 oz.	Ginger Ale
3 1/4 quarts	100 oz.	Water
1 c. sugar	8 oz.	Brown Sugar

① 8 oz. Each for 1 pupil.
② amout for 1 Classroom = 8 quarts or 2 gallons

Figure C2-11

Next we converted the twenty-five quarts needed for all three classrooms to gallons. Again, for the students who had difficulty with division, we acted out pouring four quarts into a gallon, subtracting for each time we poured. We determined that each of the three classrooms would need eight quarts, or two gallons, of our drink.

By December 17 we were ready to increase our one-quart recipe to an eight-quart recipe. The children worked in pairs to make the calculations, and then we met together to compare their results. This led to a short skill session on multiplying fractions, using repeated addition. The problems were related to the question, "How can I increase one-and-a-half ounces eight times?" One child came to the overhead projector, multiplied 1 x 8 = 8, and then wrote the following:

$$\underbrace{\tfrac{1}{2}\quad\tfrac{1}{2}}_{1} + \underbrace{\tfrac{1}{2}\quad\tfrac{1}{2}}_{1} + \underbrace{\tfrac{1}{2}\quad\tfrac{1}{2}}_{1} + \underbrace{\tfrac{1}{2}\quad\tfrac{1}{2}}_{1} = 4$$

We finished converting our recipe to eight quarts using this same method. (See one child's work in Figure C2-11.)

Our final task was to prepare a shopping list for the mothers w' , were planning the party. To make it easier for them, we converted the ounces in our recipe to packages, bottles, and jars.

On the day of the party the group that had developed the winning recipe made six gallons of our drink. The other fifth graders enjoyed our refreshment, saying it was a good party drink; their only complaint was that the gelatin had not completely dissolved. Nevertheless, we were all quite pleased with our work. All the time we had spent on our calculations paid off. This was one party where there was plenty of drink for everyone.

3. LOG ON SOFT DRINK DESIGN

by Robert Farias*
Adams School, Grade 6
Lexington, Massachusetts
(September - December 1972)

ABSTRACT

To prepare for making a carbonated drink to sell in the school cafeteria, this class of sixth graders first experimented with Kool-Aid drinks. From their mixing sessions, the children noted the importance of standardizing measurements and recording recipes. When several groups had developed drinks, the class conducted a blindfold taste test to choose the best one. Weighted values were given to the ratings of good, fair, and poor, and the votes were tallied. The children next devised a questionnaire and surveyed a sample of the school population to find (1) the demand for a soft drink, (2) the drink preferences of other students, and (3) the prices students were willing to pay. Analyzing the results led the students to conduct a confusion test between Coke and Pepsi. A confusion matrix was used for recording data. After further mixing with syrup and carbonated water, the class again used a weighted voting procedure to identify the best drinks and the best combination of ingredients. To prepare for the sale of grape and orange drinks in the school cafeteria, the children worked in one of four groups--Advertising and Marketing, Bottling, Cost, and Dispenser. Prior to their cafeteria sale, the class held a mock sale and worked out final details. The popularity of their drinks was so great that in order to serve all potential customers, the class had to hold a second sale several days later.

After a long, hot recess period, my sixth graders asked to get drinks at the water fountain. Their requests provided me with an opportune setting in which to pose the Soft Drink Design challenge. When I asked whether they would be interested in making a soft drink that tasted good and was inexpensive, the students responded enthusiastically that it was a great idea.

*Edited by USMES staff

ERIC Full Text Provided by ERIC

We first discussed what kind of drink the children would like to make. They unanimously elected to make a tonic (a carbonated drink), although they admitted they had little notion of how to make such a drink. For several minutes we talked about drinks that their mothers prepared at home and one student suggested concocting a new Kool-Aid drink. The other students agreed that experimenting with Kool-Aid drinks would give us experience for tonic production later on.

We gathered the necessary materials and ingredients, and that afternoon several groups of children began to make Kool-Aid drinks. Using various quantities of Kool-Aid, water, and sugar, they experimented to find a combination that tasted good. Some groups used crude measuring techniques to determine the quantities of ingredients added; others didn't bother to measure at all. When I asked the children to reproduce their mixtures for a class sampling, most groups found that they couldn't. Either the magic formula had not been written down, or their rough measures of ingredients could not be duplicated. Several students were very annoyed because I hadn't directed them to write down a formula as they mixed.

Since most of the children had been able to sample at least some of the drinks concocted, we talked about the significance of various ingredients used in the mixtures. They realized that varying amounts of the same ingredients changed the taste of drinks. Some children thought that a drink should have lots of sugar in it; others disagreed, and so I asked how we could decide whether sugar was an important factor. They suggested that each group make one drink, record the recipe, and then submit their drink to a taste test. Each drink could be rated and the ingredients of the "best" mixture could then be studied to determine its sugar content. This analysis would indicate how important sugar was to the taste of a drink.

The following day we again concocted batches of Kool-Aid, and the groups chose their own methods for recording recipes. Some children took meticulous notes on the ingredients they added and the procedures they followed--they even managed to keep their notes out of the large puddles of Kool-Aid.

To check the accuracy of their recipes, the groups made their new mixtures twice and compared the tastes of the first and second batches. None of the second-round drinks tasted exactly the same as the first. Some children felt strongly that certain drinks were just intrinsically difficult to reproduce. However, some pairs of drinks were more similar tasting than others, and we tried to explore the reasons for this. Naturally those drinks that had been more carefully mixed had more similar tastes. This observation led the children to conclude that a recipe could be easily duplicated if good measuring tools were used carefully. Some children suggested that the best tools might be those used in kitchens, e.g., measuring spoons and cups. Several students offered to bring some to class, and I agreed to contribute some small cups marked in ounces.

In our third session, eight groups of children again mixed Kool-Aid drinks, this time using measuring cups or spoons and carefully recording recipes. To make a large enough quantity for everyone in class to have a taste, the groups made several separate servings of their recipes and then combined the single drinks in bottles. I was surprised that no group thought of simply multiplying their original formula to accommodate a larger number of people. It was only in discussing mixing procedures later that the students realized they could have easily made a large batch of any drink just by expanding their recipe proportions.

Many points were raised by the children when we discussed a fair method to choose the best drink. As noted above, the class hypothesized that if the best drink could be distinguished, an analysis of types and quantities of ingredients might suggest why it was the most popular. Many children were concerned, however, that each person would choose his/her own drink and, therefore, our analysis would be biased. One boy suggested, "We could blindfold people and have them see if they could tell them apart."

Thus, there were two purposes for the drink taste test: (1) to find the best drink and (2) to identify one's own drink. Many students wanted to test to see whether individuals could really distinguish their own drinks; others argued that the original test objective was to determine the best drink. These children felt, and the others finally agreed, that if everyone were honest, the answers would be truthful. Even if people chose their own drinks, it would be because they liked them best.

We next considered how to rate the drinks. Some students suggested using letter grades, A, B, C, etc., but others felt that with eight drinks to taste, this method would be too confusing. Everyone finally agreed with another suggestion, to grade the drinks "good" and "bad," and we decided to add a "fair" rating for "in-between" drinks.

The taste test then began. Each bottle of drink was labeled with a number and the recipe was attached. One student poured samples into cups while another student held up the number of the drink being tested by each blindfolded taster.

Meanwhile, the rest of the students kept a tally of the ratings. Methods for recording the votes were left up to the individual. The children planned to single out the most efficient tally method, then mimeograph and distribute copies for the entire class.

When the testing was completed, the students totaled the good, fair, and poor votes for each drink and converted the votes in each category to percentages. After identifying the most popular drinks, we looked at the recipes and noticed that all contained large amounts of sugar. The students concluded, then, that sweetness was an important factor and thus sugar, an important ingredient.* They also mentioned coldness as an important characteristic.

The next day one of the girls suggested that our class try to offer our future soft drink as an alternative to the milk sold in the cafeteria. Most of the class thought her idea was great. Someone else added that we could use the proceeds from our sales to finance a camping trip we were planning for the end of the year.

The question then was how to determine what kind of drink the other students would buy. A survey was proposed. Most of the children remembered being polled the previous year when my class of fifth graders had also worked on Soft Drink Design. Recalling that two surveys had been taken, they asked why. I explained that the class last year had not been satisfied with the first survey results. One of their questions had asked for favorite flavors to be listed; however, so many flavors were mentioned that the children couldn't begin to sort out important ingredients to put into a new drink.

We talked at length about the purpose of our own poll, finally concluding that our survey questions should be to the point and carefully devised. If the drink preferences of the school population could be accurately identified, we figured we could use this information to make a popular new drink.

*To determine other factors, the children might rate the similarity (or difference) between pairs of drinks. If all possible pairs are tested (each pair rated as being very similar, slightly different, or very different), the data can be used to construct a drink difference map. See Background Paper DP3, *Determining Taste Factors for Soft Drink Design*.—ED.

Soda Survey

(1) Do you like soda? ☒ Yes ☐ No

(2) How much would you pay for a soda you like? 65¢

(3) Name your Four Favorite Soda's

1st Gingerale
2nd Coac acoka
3rd Orang ade
4th Root bear

Figure C3-1

Four groups of students made up several survey questions that were then reviewed by the entire class and either accepted or discarded. The first question--"Do you like soda?" --was designed to find out whether there was a demand for a soft drink at our school. If there were a demand, then the second question--"List your favorite sodas in the order that you like them"--served to define the components of that demand. Then, remembering the difficulties of the class last year, the students decided not to ask such an open-ended question, and they limited the flavor choices to the top four preferences. Our last question asked how much people would pay for a can of soda they liked. (See copy of survey in Figure C3-1.)

When the final draft of the survey had been completed, we decided to have a trial run in our own classroom. That way, the children reasoned, we could figure out the best method to keep track of the survey results. Everyone filled out a survey, and the class divided into groups, each group using its own method to tally the results. Afterwards, we evaluated each tally method.

Since question two about drink preferences allowed four choices, we spent quite a bit of time discussing whether a vote for fourth place should have the same significance as a first place vote. After much deliberation, the students decided to allot points to each vote according to its place. Thus, a first place vote received four points, a second place vote three points, etc. Everyone was satisfied with this weighting system; we felt it would allow us to determine fairly the popularity of each drink.

We next faced the problem of survey distribution. Who would be polled? The children argued for one of two options: (1) survey only the upper grades because the little children might have a very hard time reading our questionnaire; (2) survey everyone in school because everyone drinks soda and might buy our drink. Those arguing for option one won the debate, but we soon discovered that some second graders were mixed in with third-grade classes. We decided that they, too, could participate in our survey. With this issue settled, a group of students visited the appropriate teachers to find out the number of children in each class and to obtain permission to conduct a five-minute survey.

By the beginning of October we were able to conduct our survey. The class divided into ten groups to visit the ten classrooms on our list. Each group was responsible for collecting and tallying their own data. To decide fairly which group would survey which classroom, we numbered the groups and drew numbers out of a hat.

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Mrs Alder	1st	2nd	3d	4th	Total
Root beer	7	6	3	5	57
Pepsi	1	0	0	1	5
Coke	7	5	1	2	47
orange	3	6	6	3	45
Sprite	2	0	1	0	10
Ginger ale	0	0	1	2	4
grape	0	3	8	8	33
7up	1	0	1	0	6
others	2	1	0	1	12

Figure C3-2

The groups later reported their tallies, and we recorded the data on large master charts drawn on the chalkboard. Because the students wanted to keep their own tallies of the results, I dittoed copies of our chart for everyone. For the second question on drink preferences, we listed each drink and then made four columns to record the weighted votes. One member from each group called out the votes from a class; for example, root beer--four firsts, three seconds, two thirds, five fourths. The children then added up the total number of points for root beer (thirty-four points). Each group reported in a similar manner for all the sodas and for all the classes surveyed. There was a great competitive feeling among the children as they rooted for their own favorite drink to finish first among the total school population. (See one group's tally sheet for one class in Figure C3-2.) The top four sodas, in order of weighted totals tallied from ten classes, were orange, root beer, cola, and grape. The scores for these top drinks and for other runners-up are listed below.

Drink	Weighted Total
Orange	330
Root Beer	322
Coke	302
Grape	272
7-Up	132
Ginger Ale	99
Pepsi	98
Sprite	80
Others	155

When we looked at the results, several children wondered why Pepsi had received considerably fewer votes than Coke. I asked whether they could really tell the difference between Coke and Pepsi if they were blindfolded. Most said that they could, but they wanted to try a blindfold taste experiment just to be sure..

Prior to beginning the blindfold test on the following day, we spent some time resolving procedural questions. The students decided that Coke and Pepsi should be sampled in a random order to minimize the chance of the brand being detected. Several methods of tallying were considered, and, at this point, I conducted a skill session on making a confusion matrix. To illustrate its function, I asked a student to write heads and tails on the board. As we flipped

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a coin, I asked one child to call out "heads" or "tails" and we tallied the correct and incorrect calls on the appropriate section of the matrix.

Separate blindfold taste tests were then conducted by several groups of students. All children had an opportunity both to be blindfolded and to keep their own records of the test results. As each group completed their testing, they tallied their data on a large confusion matrix I'd drawn on the chalkboard.

Having totaled the final results, we discovered there were fifty-four correct brand guesses and forty-three incorrect guesses. As shown in Figure C3-3, we also calculated the percentage of correct guesses--55 per cent.

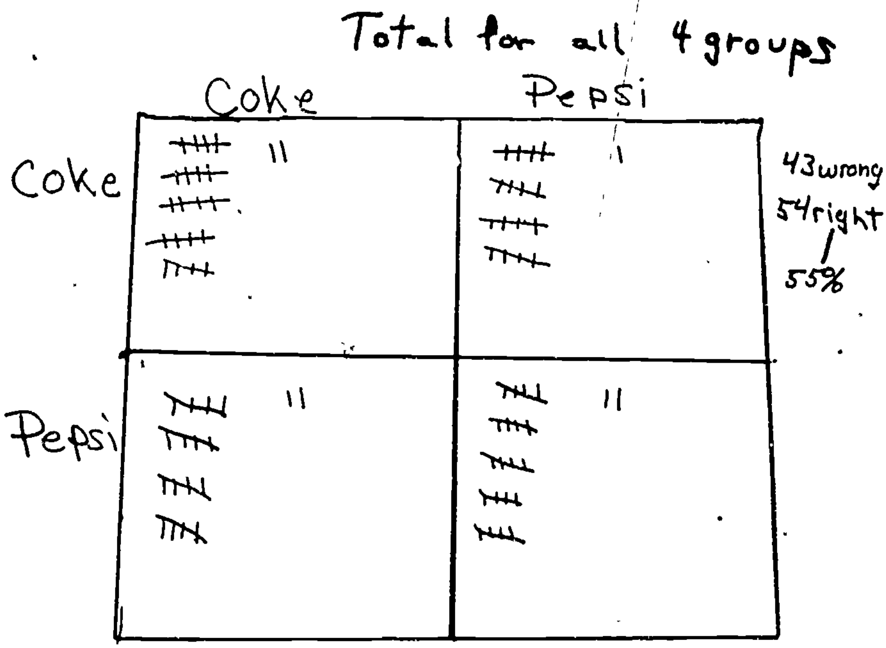

Figure C3-3

It seemed that Coke and Pepsi indeed had very similar tastes. The children were perplexed over the poor survey rating of Pepsi. We explored factors that might affect the popularity of Pepsi. The children acknowledged that Coke's popularity was partially due to advertising, yet they felt that Pepsi had also been widely publicized on television.

The children then wondered whether they could distinguish between Coke and a cheaper cola, such as a supermarket brand.

If Coke were not different in taste from a cheaper brand, they said they would buy the more inexpensive cola. A new blindfold test was proposed using Coke, Pepsi, and a cheaper brand of cola.*

From our survey and blindfold test data, we knew that most children were interested in a cold, sweet carbonated drink. The class decided to devise their new tonic by mixing ZaRex and club soda. The new drink mixture would be easy to make because there were only two ingredients, and, when refrigerated, it would have the characteristics needed in a popular drink: coldness, sweetness, and carbonation.

Our return to the adventures of drink design proved almost as disastrous as our first experiments with Kool-Aid. Recipes weren't kept, the bubbles in our club soda kept dying on us, and measuring techniques were not standardized. Our second attempts were better. The class worked in four groups, each using one of the flavor choices--grape, cherry, lemon-lime, and orange. All groups made several drinks, with different proportions of syrup and soda water. Group members then tasted their concoctions and selected the best tasting one for our class taste test.

During the mixing, the lemon-lime group began to worry that their club soda was going flat; they were anxious not to have dead soda polluting their creation. They resolved their doubts by blindfolding two boys and asking them to try to distinguish a difference in taste between two bottles of club soda, one freshly opened and one suspected of being flat. The group found that one bottle of club soda was indeed flat; they put that one aside and continued their mixing activities using the "non-flat" soda.

When we submitted the four drinks to a class taste test, we used the same ratings as previously (good, fair, poor). The groups rated only other groups' drinks, not their own. After the results were tallied on the board, we also wrote the proportions of syrup and tonic used in each drink. The children thought that by comparing the voting results with the drink formulas, we could distinguish the best combinations of syrup and club soda.

*The results of this test were not included in the teacher's original log.--ED.

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	VOTING			FORMULAS	
	Good	Fair	Poor	Syrup	Tonic
Grape	0	5	15	$1\frac{1}{2}$	8
Orange	14	4	2	2	9
Black Cherry	1	7	12	3	9
Lemon-Lime	9	6	5	2	8

The children decided, on the basis of these results, that a 1:4 ratio of syrup to tonic made a good drink mixture. One girl objected, saying that the grape ratio was very close to that. She wondered whether we shouldn't consider using a proportion of $1\frac{1}{2}$:8. She and I played with some numbers for several minutes and discovered that the grape recipe called for almost 25% less syrup than the 1:4 ratio. We agreed that the two ratios were actually very different.

After again reviewing the results of our sample survey of the school, the students decided that the preferred flavors, grape, orange, or lemon-lime, mixed in 1:4 ratios of syrup to tonic, would make popular drinks to sell in the school cafeteria. Black cherry was eliminated because the survey indicated it was not well liked. To choose which of the three drinks to sell, several students mixed batches of each flavor and ran a taste test in another classroom. Since lemon-lime rated very poorly in this test, the class agreed to make orange and grape drinks. (Unfortunately, no root beer syrup was available for them to use to mix the second most popular drink in the school.)

Names for our drinks were selected by a class contest. The children placed their ideas for one drink at a time in a suggestion box and then we wrote them on the board. Before we voted, I asked whether the winner would be chosen by majority or plurality. Several children who understood the difference explained to their classmates. We decided to have a preliminary vote with the two top names, chosen by plurality, to be used in a second vote. "Orange Cooler" received the majority vote in our second balloting for our orange-flavored drink.

To carry out various tasks involved in the manufacture and sale of our drinks, the children formed four groups, Advertising and Marketing, Bottling, Cost, and Dispenser. Each group's activities are described in the following paragraphs.

<u>Advertising and Marketing Group</u>

The main concern of this group was to inform the school population that we were making new drinks to sell in the school cafeteria. Group members debated also trying to market our drinks for the parent population associated with our school, but they decided to limit the first trials to our own student body.

The advertising campaign was contrived to build up curiosity. Signs and posters were made with the following slogans:

- "It's coming..."
- "Guess who's coming to dinner?"
- "Look for a secret."
- "Look, save your allowance for a treat at lunch."
- "Coming soon from Room 201. Beware."

The posters were evaluated by other class members and improvements were made according to the suggestions.

Three girls, who had volunteered to place the posters around the school, reported to the class on their plans. They said they had selected places where many people passed, such as the cafeteria, bathrooms, and the doors of classrooms. I mentioned that I didn't have a clear idea of exactly where the signs would be, and someone suggested making a map of the sc'ool. The three girls immediately began work on a map, adding that the posters would be displayed when we had received permission for our sale from the school administration.

Additional posters, made for displaying the week before we had our sale, announced the arrival of our drinks. This second set of signs led to an interesting discussion about truth in advertising. Several children developed slogans using famous people's names, e.g., "Jim Plunkett likes our drink" and "Johnny Bench likes our orange-flavored drink." When one student questioned whether this could be called false advertising, one of the slogan makers quickly said he knew someone in our town named Johnny Bench. However, since most people wouldn't associate that name with a town resident, the children decided against using personal endorsements that weren't true.

<u>Bottling Group</u>

Thinking that our new drinks might eventually be sold in two markets, at school and in homes, the Bottling Group decided that two kinds of packaging were needed. Drinks sold at school would be served in small paper cups; thus, the most immediate question was solved. Since we abandoned the idea of selling drinks to parents, this group didn't have to solve the problem of devising a second type of packaging.

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Group members began bringing used bottles from home for storing our mixed drinks. However, after discussing the cleanliness of the operation, they decided to scratch this idea for sanitary reasons. No matter how much the bottles were washed, the children felt they couldn't guarantee that the bottles were clean. Instead, they used our own empty soda water bottles.

Cost Group

This group investigated the production costs of making our drinks so that the class could decide on a selling price. They began by calculating the cost per ounce in each bottle of ZaRex and in each bottle of soda water. Then they figured the number of ounces of each ingredient needed to make one cup of drink. Finally, they were able to report a production cost of just under 1¢ per ounce of new drink made. The chief student financier explained that sixteen eight-ounce cups of drink could be made from ingredients costing $1.11. That meant a production cost of 7¢ per eight-ounce cup. By charging 8¢ per serving, we would make a penny profit on each cup sold.

Some students were alarmed by the cost. We knew from our survey results that most people were willing to pay 15¢ for a drink they liked, but we also realized that a can or bottle contained more soda than our eight-ounce cups. True, we would have a monopoly and many people would buy our drink just out of curiosity, but we would still be competing with the lower price of milk. We discussed our situation:

Student:	It will cost more than milk. More milk costs less.
Student:	But lots of kids don't like milk.
Teacher:	Well, how could we make it cheaper?
Student:	Teachers have to pay 10¢ for milk. They might buy it.
Student:	Riddle cups are more expensive.
Student:	My uncles own a shop.
Teacher:	Maybe then, you could find out from them the cheapest price of five-ounce cups.

The student's uncles did help us to obtain lower-priced cups, but we still had a production cost of 5¢ per five-ounce cup. Adding one penny profit, we would have a selling price of 6¢ per cup. This was a deflating profit margin for the class. The students figured out that to make one dollar profit, we'd have to sell 100 cups. At this rate, the treasury for our field trip wouldn't be boosted by any huge amount.

The children decided that if everyone in class donated some of the ingredients, we wouldn't have any production cost at all. Then everything we made from our sale would be pure profit. When everyone agreed, the price for our drinks was set at 5¢ per cup.

Dispenser Group

Children in this group tried designing a drink dispenser that would pour the correct 1:4 ratio of syrup to carbonated water. They thought that two tubes of differing widths could be used to control the flow of the two liquids.

They first poured a measured amount of carbonated water through the nozzle of a milk bottle and timed how long it took. After repeating the procedure ten times, they calculated a median time of five seconds. Hypothesizing that the soda water might flow four times faster than the same amount of syrup, they thought they would have an easy way to produce large batches of drinks.

The trials were repeated, this time pouring the same amount of syrup. The median time for syrup was nine seconds. Thus, the syrup flowed only about twice as slowly as the carbonated water. The students tried taping a straw to the nozzle of a bottle to slow the flow of syrup. It worked too well, slowing the syrup flow to ninety seconds. After discussing why the syrup took so long, the children decided to try again and to use a stopwatch for more accurate timing.

After comparing the straw with a commercial nozzle, they punched an air hole in the straw. Unfortunately, the hole let out as much syrup as it let in air; so it was back to the drawing board for this group. The children continued their search for ways to regulate the flow of syrup and carbonated water, but encountering one failure after another, the Dispenser Group finally abandoned their plans.

Since the dispenser idea had not worked out, the class met to decide on another method of preparing our drinks.

> Student: We could make them here in class in big jugs, then bring them down to the lunchroom.
> Student: They might get spoiled.
> Student: They might be better cold.
> Student: A lot of people won't like it if they're warm.

This discussion led to a debate about the importance of carbonation and how long the "fizz" would last. Consequently, we decided to organize another blindfold test. Students first mixed two batches of drinks, one following our recipe with soda water and the other with plain tap water substituted for the soda water. After four minutes, we blindfolded four children and recorded their confusions. Even when the last child was tested after nine minutes, there was no confusion; all could identify which drinks were carbonated.

Wondering whether we could distinguish a difference in taste between a freshly made carbonated drink and one that had been sitting for a while, we tried another blindfold test. Of the sixteen guesses, only five correctly identified the fresh drink from the "old" one. We therefore concluded that using tap water instead of soda water would indeed produce a noticeable change in our drinks; however, the soda water retained its carbonation long enough so that we shouldn't have any problem if we mixed our drinks a short time in advance of our sale.

Other details also had to be worked out. Although we had not received permission to sell our drinks in the cafeteria, we felt fairly confident of the school administration's approval. A precedent had been set the previous year when another teacher's class had sold drinks. Several children volunteered to write a letter to the principal explaining our plans for the sale and the use of our profits. Permission was granted.

Next we needed to select a location for our sales tables. Several students went to measure the available spaces in the cafeteria to determine the most convenient setup. They were quickly in conflict with the custodian, who, thinking we would create a big mess, wanted us to use tables at the extreme rear of the cafeteria. The students were very upset by this idea--we would not be able to compete with the milk sales nor would we be accessible to the hot lunch line. When the children explained that his plan would wreak havoc with the regular cafeteria procedure because many students would cut through the regular lines to reach our sales table, the custodian relented. We were allowed to set up tables in two locations, one near the hot lunch counters and the other near the milk line.

Our surveys had indicated that orange-flavored drink was more popular than grape. However, to be sure that we should really make a larger quantity of orange, the children resurveyed the upper grades. The results showed that orange was still the favorite.

To be certain that all the details and selling procedures had been clearly worked out, the class held a mock sale in the cafeteria. Three people worked at each table, one to collect money, one to pour drinks into cups, and one to give the drinks to the customers. We found that each table also needed an additional person to serve as runner, replacing empty bottles with full ones from the nearby freezer where we stored our drinks. Our mock sale reminded us that we would also need change for each table. The children decided that everyone in class would buy a drink for five cents, and we could use that money for our change.

The children who weren't working at one of the two tables had the first opportunities to mix up our drinks. They used small paper cups to pour ingredients into the bottles, one cup syrup to four cups soda water. Meanwhile, several members of the Advertising Group visited other classes to remind students about our sale on the following day.

The sale day came, and we were all surprised that within the first lunch period all our drinks had been sold. The $12.35 we collected meant that we sold 247 cups of drinks. We just hadn't anticipated the overwhelming popularity of our drinks. Our surveys had indicated that approximately 250 students would buy our soda, but we hadn't considered that people might buy more than one drink.

Another thing that caught us by surprise was that most customers wanted grape rather than orange drink. This ran contrary to our own surveys that showed orange was the favored soda. The children felt that the preference for grape was not because of the taste of their orange drink (they had tasted it before the sale, and it was good) nor because of the color (it looked normal). We could find no apparent reason for the popularity of the grape drink.

Since none of the fourth, fifth, or sixth graders who ate during the second lunch period had been able to buy our drink, we held another sale just for them a few days later. Our second sale was as successful as the first. Our profits went towards our field trip fund and helped us to have a buggy, dusty, but really good, four-day camping trip.

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D. References

1. LIST OF "HOW TO" CARDS

Below are listed the current "How To" Card titles that students working on the Soft Drink Design challenge might find useful. A complete listing of both the "How To" Cards and the Design Lab "How To" Cards is contained in the USMES Guide. In addition, the Design Lab Manual contains the list of Design Lab "How To" Cards.

GRAPHING

GR 1 How to Make a Bar Graph Picture of Your Data
GR 2 How to Show the Differences in Many Measurements or Counts of the Same Thing by Making a Histogram
GR 3 How to Make a Line Graph Picture of Your Data
GR 4 How to Decide Whether to Make a Bar Graph Picture or a Line Graph Picture of Your Data
GR 5 How to Find Out If There is Any Relationship Between Two Things by Making a Scatter Graph
GR 6 How to Make Predictions by Using a Scatter Graph
GR 7 How to Show Several Sets of Data on One Graph

MEASUREMENT

M 1 How to Use a Stopwatch
M 9 How to Make a Conversion Graph to Use in Changing Measurements from One Unit to Another Unit
M 10 How to Use a Conversion Graph to Change *Any* Measurement in One Unit to Another Unit

PROBABILITY AND STATISTICS

PS 2 How to Record Data by Tallying
PS 3 How to Describe Your Set of Data by Finding the Average
PS 4 How to Describe Your Set of Data by Using the Middle Piece (Median)
PS 5 How to Find the Median of a Set of Data from a Histogram

RATIOS, PROPORTIONS, AND SCALING

R 1 How to Compare Fractions or Ratios by Making a Triangle Diagram*
R 2 How to Make a Drawing to Scale
R 3 How to Make Scale Drawings Bigger or Smaller

*Presently called Slope Diagram.

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New titles to be added:

How to Design and Analyze a Survey
How to Choose a Sample
How to Design an Experiment
How to Record Data
How to Make and Use a Cumulative Distribution Graph

A cartoon-style set of "How To" Cards for primary grades is being developed from the present complete set. In most cases titles are different and contents have been rearranged among the various titles. It is planned that this additional set will be available early in 1977.

2. LIST OF BACKGROUND PAPERS

As students work on USMES challenges, teachers may need background information that is not readily accessible elsewhere. The Background Papers fulfill this need and often include descriptions of activities and investigations that students might carry out.

Below are listed titles of current Background Papers that teachers may find pertinent to Soft Drink Design. The papers are grouped in the categories shown, but in some cases the categories overlap. For example, some papers about graphing also deal with probability and statistics.

The Background Papers are being revised, reorganized, and rewritten. As a result, many of the titles will change.

DESIGN PROBLEMS

DP 3 Determining Taste Factors for Soft Drink Design (based on suggestions by Henry Pollak)
DP 13 People and Space by Gorman Gilbert

GRAPHING

GR 3 Using Graphs to Understand Data by Earle Lomon
GR 4 Representing Several Sets of Data on One Graph by Betty Beck
GR 6 Using Scatter Graphs to Spot Trends by Earle Lomon

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GRAPHING (cont.)	GR 7 *Data Gathering and Generating Graphs at the Same Time (or Stack 'Em and Graph 'Em at One Fell Swoop!)* by Edward Liddle
GROUP DYNAMICS	GD 2 *A Voting Procedure Comparison That May Arise in USMES Activities* by Earle Lomon
PROBABILITY AND STATISTICS	PS 4 *Design of Surveys and Samples* by Susan J. Devlin and Anne E. Freeny PS 5 *Examining One and Two Sets of Data Part I: A General Strategy and One-Sample Methods* by Lorraine Denby and James Landwehr
RATIOS, PROPORTIONS, AND SCALING	R 1 *Graphic Comparison of Fractions* by Merrill Goldberg R 2 *Geometric Comparison of Ratios* by Earle Lomon

3. BIBLIOGRAPHY OF NON-USMES MATERIALS

The following materials are references that may be of some use during work on Soft Drink Design. The teacher is advised to check directly with the publisher regarding current prices. A list of references on general mathematics and science topics can be found in the *USMES Guide*.

Elementary Science Study. *Changes*. New York: Webster Division, McGraw-Hill Book Co., 1968. (Order ESS materials from McGraw-Hill Distribution Center, Princeton Rd., Hightstown, NJ 08520.)
This teacher's guide explores the changes that occur in food and other substances over a period of time. Recommended for second and third grade.

____________. *Colored Solutions*. New York: Webster Division, McGraw-Hill Book Co., 1968.
Introduction to the ideas of density and the layering of liquids. Recommended for grades 3-6.

____________. *Ice Cubes*. New York: Webster Division, McGraw-Hill Book Co., 1968.
Exploration of freezing and melting of ice cubes, and of making water cold with the least amount of ice. Recommended for grades 3-5.

____________. *Mystery Powders*. New York: Webster Division, McGraw-Hill Book Co., 1967.
The activities suggested in this book deal with the properties of ordinary white powders such as sugar, salt, and starch and the use of indicators to identify them. Recommended for grades 3-4.

Minnesota Mathematics and Science Teaching Project (MINNEMAST). *Using Our Senses, Unit 4*. Minneapolis: University of Minnesota, 1967. (Order all MINNEMAST materials from Minnemast, University of Minnesota, 720 Washington Avenue, SE, Minneapolis, MN 55414.
The sense of taste is explored in Section 5. Children experiment with different foods having basic flavors and combinations of flavors. Primary level (kindergarten).

____________. *Observing Properties, Unit 8*. Minneapolis: University of Minnesota, 1967.
The activities suggested in this book cover the classifi-

cation, exploration, and testing of the properties of various materials, including liquids. Section 3, "Testing for Properties," is most applicable. Primary level (first grade).

__________. *Investigating Systems, Unit 15.* Minneapolis: University of Minnesota, 1971.
Systems of reacting and interacting components are covered in this book. Section 4, "Two Chemical Systems," deals with phenomena that occur when certain liquid and solid substances are mixed. Primary level (second grade).

__________. *Change and Calculations, Unit 24.* Minneapolis: University of Minnesota, 1971.
Section 3, Lesson 12, explores standard English liquid volume measurement (pints, quarts, gallons). Primary level (third grade).

__________. *What Are Things Made Of?, Unit 26.* Minneapolis: University of Minnesota, 1971.
This book explores the properties of materials, including hardness, shape, weight, volume, density, and solubility. Section 7, "The Property of Solubility," is most applicable. Primary level (third grade).

The Story of Soft Drinks. Filmstrip and record with leader's guide available from the National Soft Drink Association, 1101 Sixteenth St., N.W., Washington, DC 20036.
This filmstrip traces the history of soft drinks from the first attempts to produce carbonated water to present modern-day production of soft drinks.

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4. GLOSSARY

The following definitions may be helpful to a teacher whose class is investigating a Soft Drink Design challenge. These terms may be used when they are appropriate for the children's work. For example, a teacher may tell the children that when they conduct surveys, they are collecting *data*. It is not necessary for the teacher or students to learn the definitions nor to use all of these terms while working on their challenge. Rather, the children will begin to use the words and understand the meanings as they become involved in their investigations.

Average — The numerical value obtained by dividing the sum of the elements of a set of data by the number of elements in that set. Also called the mean.

Comparative Shopping — A method for determining the best buy(s) by comparing the costs, quantities, and qualities of different brands of products.

Confusion Matrix — A chart showing tallies of correct and incorrect guesses in an identification test. Example: number of times the tastes of Coke and Pepsi are confused during a blindfold test.

DRINKS GUESSED \ DRINKS TASTED	COKE	PEPSI
COKE	////	///
PEPSI	//	~~////~~ /

Consumer — A person who buys or uses goods or services.

Conversion — A change from one form to another. Generally associated in mathematics and science with the change from one unit of measure to another or the change from one form of energy to another.

Correlation — A relationship between two sets of data.

Cost — The amount of money needed to produce or to purchase goods or services.

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Data — Any facts, quantitative information, or statistics.

Distribution — The spread of data over the range of possible results.

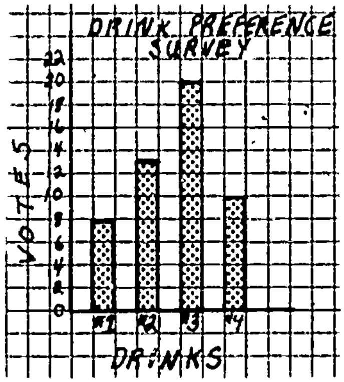
Drink Difference Map — See *Graph*.

Frequency — The number of times a certain event occurs in a given unit of time or in a given total number of events.

Graph — A drawing or a picture of one or several sets of data.

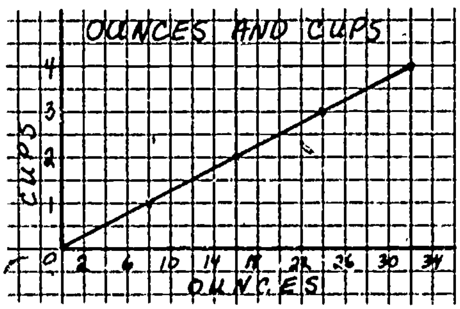
Bar Graph — A graph of a set of measures or counts whose sizes are represented by the vertical (or horizontal) lengths of bars of equal widths. Example: the number of people who vote for certain drinks in a taste test.

DRINK	VOTES
#1	8
#2	13
#3	20
#4	10



Conversion Graph — A line graph that is used to change one unit of measurement to another. For example, changing ounces to cups or vice versa.

OUNCES	CUPS
8	1
16	2
24	3
32	4

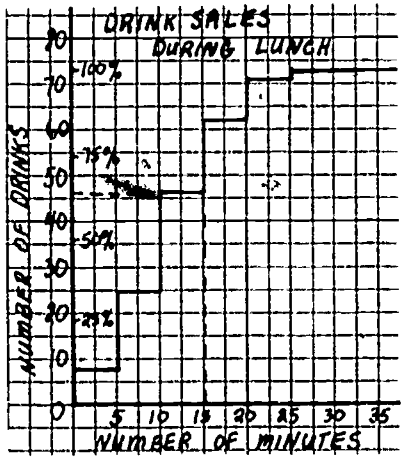


Cumulative Distribution Graph

A graph that can be constructed from a histogram by computing running totals from the histogram data. The first running total is the first value in the histogram data (see table of values). The second running total is the sum of the first and second values of the histogram, the third is the sum of the first, second, and third values, and so on. The horizontal scale on the graph is similar to that of the histogram; the vertical scale goes from 0 to the total number of events observed or samples taken (in the example, the total number of drinks sold during the lunch period). Each vertical distance on the graph shows the running total of the number of samples taken that are less than or equal to the value shown on the horizontal scale; thus the graph below indicates that forty-six, or approximately 65%, of the drinks had been sold in fifteen minutes or less.

TABLE OF VALUES

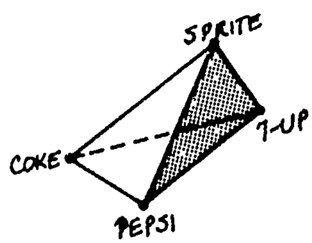
NO. OF MINUTES	RUNNING TOTALS
5 or fewer	7
10 or fewer	25
15 or fewer	46
20 or fewer	62
25 or fewer	71
30 or fewer	73



Drink Difference Map

A three-dimensional geometric picture whose points are plotted from data on taste similarities between different pairs of drinks. Children can determine taste factors (e.g., cola vs. non-cola, sweet vs. less sweet) from the map and use the information in the design of a new soft drink. (See Background Paper *DP3* for details.)

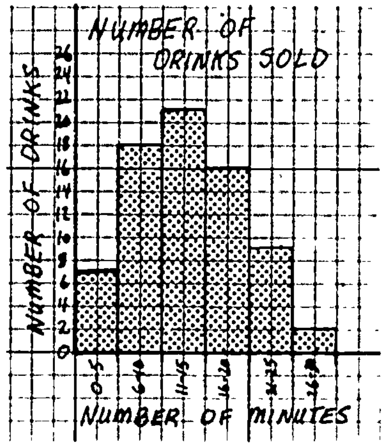
PAIRS OF DRINKS	DEGREE OF SIMILARITY
COKE-- PEPSI	APPROXIMATELY 13
COKE-- 7-UP	" 23
COKE-- SPRITE	" 20
PEPSI-- 7-UP	" 22
PEPSI-- SPRITE	" 21
SPRITE-- 7-UP	" 13



Histogram

A type of bar graph that shows the distribution of the number of times that different measures or counts of the same event have occurred. A histogram always shows ordered numerical data on the horizontal axis. Example: the different numbers of drinks sold during a thirty-minute lunch period.

NUMBER OF MINUTES	NUMBER OF DRINKS
0-5	7
6-10	18
11-15	21
16-20	16
21-25	9
26-30	2

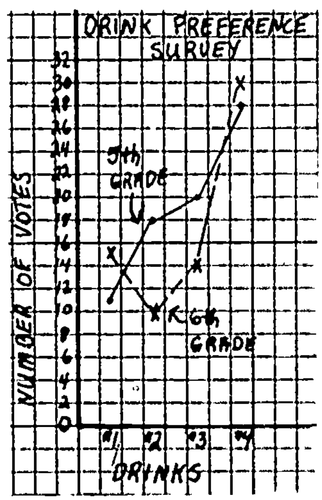


Line Chart

A bar graph that is represented by circles, crosses, or triangles with lines connecting them so that it has the appearance of a line graph. (See *Line Graph*.) This is a useful representation when two or more sets of data are shown on the same graph. Example: preferences of fifth and sixth graders for new drinks.

DRINK VOTES

DRINK NO.	5th GRADE	6th GRADE
#1	11	15
#2	18	10
#3	20	14
#4	28	30



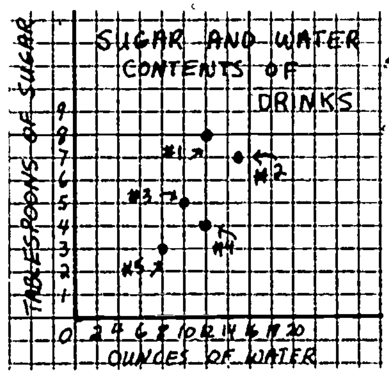
Line Graph

A graph in which a smooth line or line segments pass through or near points representing members of a set of data. Since the line represents an infinity of points, the variable on the horizontal axis must be continuous. If the spaces between the markings on the horizontal axis have no meaning, then the graph is not a line graph, but a line chart. (See *Line Chart*.)

Scatter Graph

A graph showing a scatter of points, each of which represents two characteristics of the same thing. For example, in the graph below, each point represents the amount of sugar and the amount of water in a drink recipe.

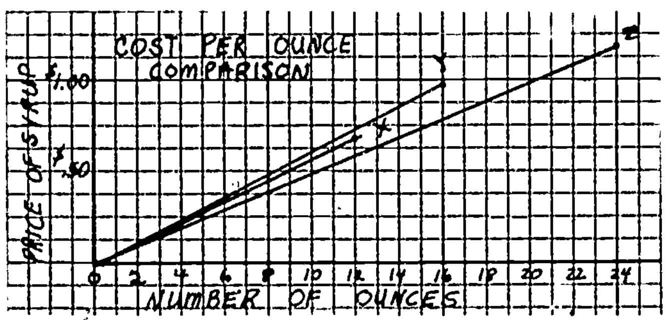
DRINK NUMBER	WATER (OUNCES)	SUGAR (TBSP)
# 1	12	8
# 2	15	7
# 3	10	5
# 4	12	4
# 5	8	3



*Slope Diagram**

A graphical means of comparing fractions or ratios. To represent the ratio a/b, plot the point (b,a) and draw a line from (b,a) to the origin, (0,0). The slope of this line represents the ratio a/b. By comparing slopes of several lines, different ratios can be compared; the less steep the line, the smaller the ratio. For example, the diagram shows the ratio of price to ounces for different sizes of a syrup brand. The ratio of price to ounce for size Z is smaller than that for sizes X or Y, and therefore, size Z costs the least per ounce.

SIZE	OUNCES	PRICE
X	12	$.69
Y	16	$.99
Z	24	$1.19



*Formerly called Triangle Diagram.

Gross Profit	See *Profit*.
Histogram	See *Graph*.
Hypothesis	A tentative conclusion made in order to test its implications or consequences.
Inference	An assumption derived from facts or information considered to be valid and accurate.
Inventory	The quantity of goods or materials on hand.
Investment	The outlay of money for a future financial return.
Mapping	Assigning each element in one set of data to a corresponding element in another set.
Marketing	The study or implementation of the most profitable and efficient methods of directing goods from manufacturer to consumer.
Market Research	The compilation of statistical information concerning consumers or purchasers.
Mass Production	The process of making something in quantity.
Matrix	A chart of data arranged in rows and columns.
Mean	See *Average*.
Median	The middle value of a set of data in which the elements have been ordered from smallest to largest. The median value has as many elements above it as below it.
Merchandising	Identifying and meeting market needs in terms of products and subsequently stimulating a demand for products through advertising, promotion, and selling.
Mode	The element or elements in a set of data that occur most often.
Ordered Set	A set of data arranged from smallest to largest.
Per Cent	Literally per hundred. A ratio in which the denominator is always 100, e.g., 72 percent = 72/100 = 0.72 = 72% , where the symbol % represents 1/100.

Percentage	A part of a whole expressed in hundredths.
Population	Any group of objects (e.g., people, items) or events from which samples are taken for statistical measurement.
Probability	The likelihood or chance (expressed numerically) of one event occurring out of several possible events.
Profit	The excess of monetary returns over expenditures; the excess of the selling price of goods over their cost. (Often called net income.)
Gross Profit	The profit reported before deduction of the indirect costs of doing business.
Profit Margin	Profit expressed as a percentage of total sales revenue.
Proportion	A statement of equality of two ratios, i.e., the first term divided by the second term equals the third term divided by the fourth term, e.g., 5/10 = 1/2. Also a synonym for ratio: when two quantities are in direct proportion, their ratios are the same.
Quartile	
First	The first quartile is the value of the quarter-way piece of data in an ordered set of data.
Third	The third quartile is the value of the three-quarter-way piece of data in an ordered set of data.
Interquartile Range	The range or length of the middle 50% of an ordered set of data; the difference between the first and third quartile.
Range	Mathematical: the difference between the smallest and the largest values in a set of data.
Rank	To order the members of a set according to some criterion, such as size or importance. Example: to put pieces of data from smallest to largest.
Ratio	The quotient of two denominate numbers or values indicating the relationship in quantity, size, or amount between two different things. For example, the ratio of the number of children who prefer a particular drink to the number of children tasting might be $\frac{10}{25}$ or 10:25.

Retail Price — The price level of goods sold in small quantity to the consumer.

Sample — A representative fraction of a population studied to gain information about the whole population.

Sample Size — The number of elements in a sample.

Scale — A direct proportion between two sets of dimensions (as between the dimensions in a drawing of a classroom and the actual room).

Scale Drawing — A drawing whose dimensions are in direct proportion to the object drawn.

Set — A collection of characteristics, persons, or objects. Each thing in a set is called a member or an element.

Statistics — The science of drawing conclusions or making predictions using a collection of quantitative data.

Tally — A visible record used to keep a count of some set of data, especially a record of the number of times one or more events occur. Example: the number of votes for each new drink.

Wholesale Price — The price level of goods sold in large quantity to a merchant for resale.

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E. Skills, Processes, and Areas of Study Utilized in Soft Drink Design

The unique aspect of USMES is the degree to which it provides experience in the process of solving real problems. Many would agree that this aspect of learning is so important as to deserve a regular place in the school program even if it means decreasing to some extent the time spent in other important areas. Fortunately, real problem solving is also an effective way of learning many of the skills, processes, and concepts in a wide range of school subjects.

On the following pages are five charts and an extensive, illustrative list of skills, processes, and areas of study that are utilized in USMES. The charts rate Soft Drink Design according to its potential for learning in various categories of each of five subject areas--real problem solving, mathematics, science, social science, and language arts. The rating system is based on the amount that each skill, process, or area of study within the subject areas is used--extensive (1), moderate (2), some (3), little or no use (-). (The USMES Guide contains a chart that rates all USMES units in a similar way.)

The chart for real problem solving presents the many aspects of the problem-solving process that students generally use while working on an USMES challenge. A number of the steps in the process are used many times and in different orders, and many of the steps can be performed concurrently by separate groups of students. Each aspect listed in the chart applies not only to the major problem stated in the unit challenge but also to many of the tasks each small group undertakes while working on a solution to the major problem. Consequently, USMES students gain extensive experience with the problem-solving process.

The charts for mathematics, science, social science, and language arts identify the specific skills, processes, and areas of study that may be learned by students as they respond to a Soft Drink Design challenge and become involved with certain activities. Because the students initiate the activities, it is impossible to state unequivocally which activities will take place. It is possible, however, to document activities that have taken place in USMES classes and identify those skills and processes that have been used by the students.

Knowing in advance which skills and processes are likely to be utilized in Soft Drink Design and knowing the extent that they will be used, teachers can postpone the teaching

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of those skills in the traditional manner until later in the year. If the students have not learned them during their USMES activities by that time, they can study them in the usual way. Further, the charts enable a teacher to integrate USMES more readily with other areas of classroom work. For example, teachers may teach fractions during math period when fractions are also being learned and utilized in the students' USMES activities. Teachers who have used USMES for several successive years have found that students are more motivated to learn basic skills when they have determined a need for them in their USMES activities. During an USMES session the teacher may allow the students to learn the skills entirely on their own or from other students, or the teacher may conduct a skill session as the need for a particular skill arises.

Because different USMES units have differing emphases on the various aspects of problem solving and varying amounts of possible work in the various subject areas, teachers each year might select several possible challenges, based on their students' previous work in USMES, for their class to consider. This choice should provide students with as extensive a range of problems and as wide a variety of skills, processes, and areas of study as possible during their years in school. The charts and lists on the following pages can also help teachers with this type of planning.

Some USMES teachers have used a chart similar to the one given here for real problem solving as a record-keeping tool, noting each child's exposure to the various aspects of the process. Such a chart might be kept current by succeeding teachers and passed on as part of a student's permanent record. Each year some attempt could be made to vary a student's learning not only by introducing different types of challenges but also by altering the specific activities in which each student takes part. For example, children who have done mostly construction work in one unit may be encouraged to take part in the data collection and data analysis in their next unit.

Following the rating charts are the lists of explicit examples of real problem solving and other subject area skills, processes, and areas of study learned and utilized in Soft Drink Design. Like the charts, these lists are based on documentation of activities that have taken place in USMES classes. The greater detail of the lists allows teachers to see exactly how the various basic skills, processes, and areas of study listed in the charts may arise in Soft Drink Design.

The number of examples in the real problem solving list have been limited because the list itself would be unreasonably long if all the examples were listed for some of the categories. It should also be noted that the example(s) in the first category--*Identifying and Defining Problems*--have been limited to the major problem that is the focus of the unit. During the course of their work, the students will encounter and solve many other, secondary problems, such as the problem of how to display their data or how to draw a scale layout.

Breaking down an interdisciplinary curriculum like USMES into its various subject area components is a difficult and highly inexact procedure. Within USMES the various subject areas overlap significantly, and any subdivision must be to some extent arbitrary. For example, where does measuring as a mathematical skill end and measurement as science and social science process begin? How does one distinguish between the processes of real problem solving, of science, and of social science? Even within one subject area, the problem still remains--what is the difference between graphing as a skill and graphing as an area of study? This problem has been partially solved by judicious choice of examples and extensive cross-referencing.

Because of this overlap of subject areas, there are clearly other outlines that are equally valid. The scheme presented here was developed with much care and thought by members of the USMES staff with help from others knowledgeable in the fields of mathematics, science, social science, and language arts. It represents one method of examining comprehensively the scope of USMES and in no way denies the existence of other methods.

REAL PROBLEM SOLVING	Overall Rating
Identifying and defining problem.	1
Deciding on information and investigations needed.	1
Determining what needs to be done first, setting priorities.	1
Deciding on best ways to obtain information needed.	1
Working cooperatively in groups on tasks.	1
Making decisions as needed.	1
Utilizing and appreciating basic skills and processes.	1
Carrying out data collection procedures--observing, surveying, researching, measuring, classifying, experimenting, constructing.	1
Asking questions, inferring.	1
Distinguishing fact from opinion, relevant from irrelevant data, reliable from unreliable sources.	1

REAL PROBLEM SOLVING	Overall Rating
Evaluating procedures used for data collection and analysis. Detecting flaws in process or errors in data.	1
Organizing and processing data or information.	1
Analyzing and interpreting data or information.	1
Predicting, formulating hypotheses, suggesting possible solutions based on data collected.	1
Evaluating proposed solutions in terms of practicality, social values, efficacy, aesthetic values.	1
Trying out various solutions and evaluating the results, testing hypotheses.	1
Communicating and displaying data or information.	1
Working to implement solution(s) chosen by the class.	1
Making generalizations that might hold true under similar circumstances; applying problem-solving process to other real problems.	1

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

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MATHEMATICS	Overall Rating
Basic Skills	
Classifying/Categorizing	1
Counting	1
Computation Using Operations	
Addition/Subtraction	1
Multiplication/Division	1
Fractions/Ratios/Percentages	1
Business and Consumer Mathematics/ Money and Finance	1
Measuring	1
Comparing	1
Estimating/Approximating/Rounding Off	1
Organizing Data	1
Statistical Analysis	2
Opinion Surveys/Sampling Techniques	1
Graphing	2
Spatial Visualization/Geometry	3
Areas of Study	
Numeration Systems	1
Number Systems and Properties	1
Denominate Numbers/Dimensions	1
Scaling	1
Symmetry/Similarity/Congruence	-
Accuracy/Measurement Error/ Estimation/Approximation	1
Statistics/Random Processes/Probability	2
Graphing/Functions	2
Fraction/Ratio	1
Maximum and Minimum Values	-
Equivalence/Inequality/Equations	1
Money/Finance	1
Set Theory	2

SCIENCE	Overall Rating
Processes	
Observing/Describing	1
Classifying	1
Identifying Variables	1
Defining Variables Operationally	1
Manipulating, Controlling Variables/ Experimenting	1
Designing and Constructing Measuring Devices and Equipment	3
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	1
Measuring/Collecting, Recording Data	1
Organizing, Processing Data	1
Analyzing, Interpreting Data	1
Communicating, Displaying Data	1
Generalizing/Applying Process to New Problems	1
Areas of Study	
Measurement	1
Motion	-
Force	-
Mechanical Work and Energy	-
Solids, Liquids, and Gases	1
Electricity	-
Heat	2
Light	3
Sound	-
Animal and Plant Classification	-
Ecology/Environment	-
Nutrition/Growth	-
Genetics/Heredity/Propagation	-
Animal and Plant Behavior	-
Anatomy/Physiology	-

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

SOCIAL SCIENCE	Overall Rating
Process	
Observing/Describing/Classifying	1
Identifying Problems, Variables	1
Manipulating, Controlling Variables/ Experimenting	2
Inferring/Predicting/Formulating, Testing Hypotheses	2
Collecting, Recording Data/Measuring	2
Organizing, Processing Data	2
Analyzing, Interpreting Data	2
Communicating, Displaying Data	2
Generalizing/Applying Process to Daily Life	2
Attitudes/Values	
Accepting responsibility for actions and results	1
Developing interest and involvement in human affairs	1
Recognizing the importance of individual and group contributions to society	1
Developing inquisitiveness, self-reliance, and initiative	1
Recognizing the values of cooperation, group work, and division of labor	1
Understanding modes of inquiry used in the sciences, appreciating their power and precision	1
Respecting the views, thoughts, and feelings of others	1
Being open to new ideas and information	1
Learning the importance and influence of values in decision making	1
Areas of Study	
Anthropology	-
Economics	1
Geography/Physical Environment	-
Political Science/Government Systems	-
Recent Local History	-
Social Psychology/Individual and Group Behavior	-
Sociology/Social Systems	-

LANGUAGE ARTS	Overall Rating
Basic Skills	
Reading	
Literal Comprehension: Decoding Words, Sentences, Paragraphs	2
Critical Reading: Comprehending Meanings, Interpretation	3
Oral Language	
Speaking	1
Listening	1
Memorizing	-
Written Language	
Spelling	3
Grammar: Punctuation, Syntax, Usage	3
Composition	3
Study Skills	
Outlining/Organizing	3
Using References and Resources	3
Attitudes/Values	
Appreciating the value of expressing ideas through speaking and writing	1
Appreciating the value of written resources	3
Developing an interest in reading and writing	3
Making judgments concerning what is read	3
Appreciating the value of different forms of writing, different forms of communication	1

KEY: 1 = extensive use, 2 = moderate use, 3 = some use, - = little or no use

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REAL PROBLEM SOLVING IN SOFT DRINK DESIGN

Identifying and Defining Problems	• Students decide that they need an inexpensive but good-tasting soft drink to serve at the party for their grade. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables.*
Deciding on Information and Investigations Needed	• Students decide that they need to determine the most popular flavors of drinks in their grade. • Students decide to mix and taste various combinations of sugar, water, and flavorings to determine which combinations make a good soft drink. • Students decide to record data on how much flavoring, sugar, and water is used in various recipes and to correlate this information with taste tests of each recipe.
Determining What Needs to Be Done First, Setting Priorities	• Students decide to survey others in their grade to determine the most popular flavor before attempting to make a new soft drink.
Deciding on Best Ways to Obtain Information Needed	• After forgetting to record the recipes for several new drinks, the children decide that one child should record the amounts of ingredients used when making up a new soft drink. • Students conduct an opinion survey to determine the most popular flavors among their schoolmates. • Children telephone or visit several stores to obtain data on costs of ingredients needed for their soft drinks.
Working Cooperatively in Groups on Tasks	• Students form groups to mix drinks using different kinds and amounts of ingredients. • Students form groups to mix large quantities of their soft drink, to determine cost of ingredients, to organize sale of soft drink.

Making Decisions as Needed

- Students decide that each group should make both a carbonated and a noncarbonated version of their soft drink.
- Students decide that a certain soft drink is the best-tasting.

Utilizing and Appreciating Basic Skills and Processes

- Students measure the ingredients needed for their soft drink using cups, tablespoons, and teaspoons as their units of measurement.
- Students use slope diagrams to compute unit costs of ingredients needed for their soft drinks.
- Students agree that a survey of other children in their grade is needed to determine preferences for flavors in order to make a drink that satisfies the most people.
- Students work together to find their own solutions to problems that occur as they mix new soft drinks.
- Students record recipes for the soft drinks they have invented.
- See also MATHEMATICS, SCIENCE, SOCIAL SCIENCE, and LANGUAGE ARTS lists.

Carrying Out Data Collection Procedures--Opinion Surveying, Researching, Measuring, Classifying, Experimenting, Constructing

- Students conduct opinion survey to determine schoolmates' preferences for popular soft drinks.
- Students devise recipes for new soft drinks.
- Students measure ingredients using standard and non-standard measurements.
- Students design a taste test to determine which drink is preferred.
- Students classify soft drinks by flavor, sweetness, carbonation, and temperature.
- Students construct a soft drink stand.
- See also MATHEMATICS list: *Classifying/Categorizing; Measuring.*
- See also SCIENCE list: *Observing/Describing; Classifying; Manipulating, Controlling Variables/Experimenting; Designing and Constructing Measuring Devices and Equipment; Measuring/Collecting, Recording Data.*
- See also SOCIAL SCIENCE list: *Observing/Describing/Classifying; Manipulating, Controlling Variables/Experimenting; Collecting, Recording Data/Measuring.*

Asking Questions, Inferring	• Students ask which new drink is preferred. They infer from taste tests that a certain drink is preferred. • Students ask which new soft drink is the best. They infer that the one that tastes the best or the one that is cheapest is best. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Distinguishing Fact from Opinion, Relevant from Irrelevant Data, Reliable from Unreliable Data	• Students recognize the qualitative aspects of data obtained from opinion surveys as distinct from data gathered through taste tests of various soft drinks. • Students recognize that a blindfold test is more effective in determining the best tasting drink because blindfolded students are not influenced by the color of the drink.
Evaluating Procedures Used for Data Collection and Analysis, Detecting Flaws in Process or Errors in Data	• Students record their soft drink recipes carefully after they find they cannot duplicate their original efforts. • Children decide that their soft drink survey needs improvement and discuss changes they need to make in it. • See also MATHEMATICS list: *Estimating/Approximating/Rounding Off.*
Organizing and Processing Data	• Students order and group opinion survey data on preferences to make bar graphs. • Students list in order of popularity taste test results and costs of several new soft drinks to decide which drinks taste best and are cheapest. • See MATHEMATICS list: *Organizing Data.* • See SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data.*
Analyzing and Interpreting Data	• Students compare data from opinion survey with data from taste tests in order to determine characteristics that a good soft drink should have. • Students decide that the taste of the soft drink should be one determining factor in choosing a new soft drink and then rank the three best tasting drinks in order of their cost so that they can choose the least expensive of the three drinks as the drink to be used.

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Analyzing and Interpreting Data (cont.)	• Students analyze bar graphs to determine taste preferences. • See MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing; Maximum and Minimum Values.* • See SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data.*
Predicting, Formulating Hypotheses, Suggesting Possible Solutions Based on Data Collected	• As a result of opinion survey data and taste tests, students predict characteristics that a good soft drink should have. • Students hypothesize that a good-tasting drink can be duplicated if measurements of ingredients are recorded accurately. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Evaluating Proposed Solutions in Terms of Practicality, Social Values, Efficacy, Aesthetic Values	• Students designing new soft drinks consider cost, taste, color, nutritional value, and ease of preparation.
Trying Out Various Solutions and Evaluating the Results, Testing Hypotheses	• Students experiment with many soft drink mixtures and test them for taste in order to find the best tasting drink. • Students test hypothesis that drinks can be duplicated exactly (if measurements are accurate) by making their drink a second time and comparing it with the original mixture. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses/Modeling.* • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Communicating and Displaying Data or Information	• Students draw bar graphs to show preferences for flavors, sweetness, colors from survey data. • Students draw conversion chart to show measurements in different units. • See MATHEMATICS list: *Graphing.* • See SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.

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Working to Implement Solution(s) Chosen by the Class	• Students mass produce drink chosen by class for party.
Making Generalizations That Might Hold True under Similar Circumstances; Applying Problem-Solving Process to Other Real Problems.	• Students find they must measure and record ingredients carefully to duplicate their drink. • Students find that they can apply graphing and surveying skills to other problems. • Students decide to make more of their new soft drink and sell it to others in the school. • Students working on Soft Drink Design apply skills acquired to work on Consumer Research. • See also SCIENCE list: *Generalizing/Applying Process to New Problems.* • See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

ACTIVITIES IN SOFT DRINK DESIGN UTILIZING MATHEMATICS

Basic Skills

Classifying/Categorizing	• Classifying soft drinks by flavor, sweetness, color, carbonation, and temperature. • Categorizing characteristics of soft drinks in more than one way. • Distinguishing sets and subsets of opinion survey data on preferences for flavor, sweetness, color of soft drink. • Using the concepts and language of sets (subsets, unions, intersections) to classify soft drinks, analyze taste factors. • See also SCIENCE list: *Classifying*. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.
Counting	• Counting votes to determine favorite new soft drink, name for soft drink. • Counting survey data on most popular soft drinks, on preferences for flavors, sweetness, carbonation. • Counting number of ounces, cups, teaspoons of ingredients needed, number of people who will attend party. • Counting to read scales on weighing scale, measuring cups, thermometer. • Counting by sets to find scale for graph axes.
Computation Using Operations: Addition/Subtraction	• Adding one-, two-, or three-digit whole numbers to find total measurement of ingredients needed, total number of drinks needed for sale or party. • Adding teaspoons, tablespoons, ounces, and cups when mixing new soft drinks. • Subtracting to find differences between predicted and actual amounts of ingredients needed to produce enough drinks for everyone at the party. • Subtracting to find differences between predicted and actual counts of drinks sold.
Computation Using Operations: Multiplication/Division	• Multiplying whole numbers to find total measurement of ingredients needed to make a large quantity of drink. • Multiplying or dividing to find scale for graph axes.

Computation Using Operations: Multiplication/Division (cont.)	• Multiplying or dividing to increase or decrease the amount produced by a recipe for a soft drink. • Multiplying (or dividing) to convert from quarts to cups (or cups to quarts) when mixing drinks. • Dividing to find number of drinks that can be made from available ingredients. • Multiplying or dividing to find amounts of ingredients needed for one cup or one recipe of soft drink. • Dividing to calculate average number of sales per day.
Computation Using Operations: Fractions/Ratios/Percentages	• Using mixed numbers to perform calculations, such as determining amount of ingredients needed when increasing recipe. • Changing fractions to higher or lower terms (equivalent fractions) to determine amounts of ingredients needed as recipe is increased or decreased. • Using fractions and ratios to convert from cups to quarts, etc. • Using fractions in graphing when comparing number of people preferring certain flavors, etc. • Using fractions when measuring cups, teaspoons, tablespoons, or ounces of ingredients. • Using slope diagrams to compare ratios of cost to quantity when figuring unit cost of ingredients. • Calculating percentage of students who prefer a carbonated or noncarbonated drink, percentage of students willing to pay a certain price for the soft drink. • Using proportions to increase or decrease a recipe.
Computation Using Operations: Business and Consumer Mathematics/ Money and Finance	• Adding and subtracting dollars and cents to perform cost analysis, to figure profit or loss, to make change when selling soft drink. • Multiplying and dividing dollars and cents to perform cost analysis on ingredients used in soft drink, to calculate and compare costs of various soft drinks invented by class, to figure profit or loss on sale of soft drink. • Dividing to find unit cost of ingredients for soft drink. • Calculating percentage of profit when selling soft drink. • Using comparison when shopping for ingredients and containers for soft drink.

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Measuring

- Using arbitrary units (e.g., markings on a paper cup) to measure ingredients for drinks during random mixing.
- Using different standard units of measure to measure drink ingredients (e.g., cups, liters, ounces).
- Using different measuring tools, such as cup, tablespoon, graduated cylinder, to measure drink ingredients.
- Reading markings on measuring cups, graduated cylinders, weighing scales, thermometers accurately.
- Timing, using a watch or a clock, to determine how long it takes a carbonated drink to become flat.
- See also SCIENCE list: *Measuring/Collecting, Recording Data*.
- See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring*.

Comparing

- Using the concept of *greater than* and *less than* in making comparisons of size of containers to be used for soft drink, amounts of ingredients in different recipes.
- Comparing opinion survey data with taste-test results to determine characteristics of a good soft drink.
- Comparing qualitative or quantitative (using a rating scale) data on preferences for flavors of soft drinks gathered from various sources such as taste tests, informal conversations, and opinion survey results.
- Comparing qualitative (unscaled) with quantitative (scaled) data.
- Comparing estimated and actual results of confusion test, estimated and actual sales of drink.
- Comparing costs of various ingredients (e.g., syrup vs. dry mix), of various recipes for soft drinks.
- Making graphic comparisons of estimated vs. actual sales per week.
- Making graphic comparisons of fractions and ratios on slope diagrams of weight or amount vs. price of various ingredients.
- See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.

Estimating/Approximating/
Rounding Off

- Estimating error in judgments on commercial drink preferences when collecting survey data.
- Estimating the number of people who will buy a soft drink.
- Estimating amount of drink needed for a party, cost of drink.

Estimating/Approximating/ Rounding Off (cont.)	• Determining when measurements of various ingredients are likely to be accurate enough for the drink to be duplicated (taste the same). • Using approximation and rounding off in measuring ingredients, in constructing a drink stand.
Organizing	• Organizing and classifying sets of ingredients to be used, information needed to produce soft drink in quantity. • Tallying votes to determine favorite new soft drink, to determine name for drink. • Tallying on bar graphs, histograms. • Tallying confusion of soft drinks on confusion matrix. • Tallying and ordering survey data on price others are willing to pay for soft drink. • Ordering opinion survey data on drink preferences to make bar graphs. • Ordering numbers on graph axes. • Ordering units of measure in terms of size such as ounces, pints, quarts, gallons or milliliters, liters. • Ordering unit costs to determine which brands and types of ingredients are least expensive. • Using a numerical scale to determine preferences. • See also SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data*.
Statistical Analysis	• Finding the mode in an ordered set of data on prices others are willing to pay. • Assessing predictability of larger sample (entire school) based on results from smaller sample (one class from each grade level). • Determining range of data on prices others are willing to pay. • Interpretation of histograms, scatter graphs, drink difference maps, cumulative distribution graphs. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.
Opinion Surveys/Sampling Techniques	• Conducting surveys on popularity of commercial soft drinks, on preferences for flavor, sweetness, color of soft drinks, on prices others are willing to pay. • Defining data collection methods, makeup and size of sample.

Opinion Surveys/Sampling Techniques (cont.)

- Devising methods of obtaining quantitative information about subjective opinions on taste preferences for soft drinks and price students are willing to pay.
- See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.

Graphing

- Using alternative methods of displaying data such as charts and graphs of measurement conversions.
- Making a graph form--dividing axes into parts, deciding on an appropriate scale.
- Obtaining information from graphs.
- Representing data on graphs.
  - Bar graph--plotting commercial soft drinks vs. number of people preferring each drink.
  - Conversion graph--plotting cups vs. ounces.
  - Cumulative distribution graph--plotting number of drinks sold vs. time.
  - Drink Difference Map--plotting degrees of similarity between pairs of commercial soft drinks.
  - Histogram--plotting possible prices of soft drink vs. number of people willing to pay each price.
  - Line chart--plotting the number of student and adult preferences for each commercial drink.
  - Scatter graph--plotting amount of sugar vs. amount of water in drink recipes; plotting amount of sugar vs. popularity (number of children preferring drink).
  - Slope diagram--plotting cost vs. weight of various ingredients to determine cost per unit weight of each ingredient.

Spatial Visualization/Geometry

- Drawing or constructing a design or a model of soft drink stand, carrier, or dispenser.
- Constructing and using geometric figures, for example, triangles, squares, circles, for soft drink labels, packaging, and advertising.
- Using geometric figures such as cubes and cylinders to understand and utilize volume when measuring ingredients and mixing drinks.
- Measuring and constructing soft drink stand using rulers, compasses, and protractors.

Areas of Study

Numeration Systems	• Using decimal system in measuring volume of ingredients, of soft drinks (metric system measurement). • Using fractions in measuring ingredients for soft drinks (cups, fractions of cups, ounces, fractions of ounces, American system of measurement). • Using decimal system in calculations involving money (e.g., cost analysis of soft drinks).
Number Systems and Properties	• See *Computation Using Operations*.
Denominate Numbers/Dimensions	• See *Measuring*.
Scaling	• Increasing or decreasing amounts of drink produced by various recipes. • Recognizing relationships of various units of measure, e.g., teaspoons, tablespoons, cups, or milliliters, liters.
Accuracy/Measurement Error/ Estimation/Approximation	• See *Measuring* and *Estimating/Approximating/Rounding Off*.
Statistics/Random Processes/ Probability	• See *Statistical Analysis*.
Graphing/Functions	• See *Graphing*.
Fraction/Ratio	• See *Computation Using Operations: Fractions/Ratios/ Percentages*.
Maximum and Minimum Values	• Finding a soft drink that satisfies the maximum number of people for a minimum cost. • Minimizing time needed to mix soft drink by mixing the maximum quantity possible with equipment available. • Maximizing profit by considering both price and number of drinks that can be sold at a given price. • Using slope diagrams to find minimum costs of ingredients.

Equivalence/Inequality/Equations	• Observing that volume of liquid in a tall thin container is equivalent to same volume of liquid poured into wide short container. • See *Comparing* and *Computation Using Operations*.
Money/Finance	• See *Computation Using Operations: Business and Consumer Mathematics/Money and Finance*.
Set Theory	• See *Classifying/Categorizing*.

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Process

Observing/Describing	• Observing and describing the different characteristics of soft drinks, such as color, flavor, sweetness. • Observing differences in temperature of refrigerated and unrefrigerated soft drinks by reading a thermometer. • Observing that there are many possible ingredients that could be used in a soft drink, some dry, some liquid; observing differences in these ingredients. • Describing the steps in making a new soft drink. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.
Classifying	• Classifying flavors as fruity, cola, root beer. • Classifying drinks as carbonated or noncarbonated. • Determining which ingredients are necessary, which taste best when mixing soft drinks. • Classifying types of possible containers (cups, bottles, envelopes) according to different ways (dry or wet) drink can be sold. • See also MATHEMATICS list: *Classifying/Categorizing*. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.
Identifying Variables	• Identifying amounts of ingredients as variables to be manipulated or controlled when making a soft drink. • Identifying flavor, sweetness, carbonation, temperature, as possible characteristics of soft drinks that must be investigated to determine which ingredients to use in mixing soft drinks. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables*.
Defining Variables Operationally	• Defining amounts of dry ingredients in recipes as that measured in tablespoons, teaspoons, cups, ounces (weight), grams. • Defining flavors as fruity (cherry, strawberry, orange, grape, lemon/lime), cola, root beer, etc., according to flavors of popular commercial drinks.

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Defining Variables Operationally (cont.)	• Defining sweetness by the amount of sugar added to drink as measured in cups, tablespoons, grams, etc. • Defining carbonation by amount of carbonated water added to drink as measured in cups, liters, quarts, ounces. • Defining temperature of soft drink as the temperature measured by a thermometer placed in soft drink.
Manipulating, Controlling Variables/ Experimenting	• Creating new flavors by mixing combinations of several flavors. • Adding different amounts of flavoring while keeping other ingredients the same and taste testing to determine amount of flavoring preferred by most people. • Adding different amounts of sugar to soft drink while keeping other ingredients the same and taste testing to determine amount of sweetness that is preferred by most people. • Adding different amounts of carbonated water to soft drinks while keeping other ingredients the same and taste testing to determine amount of carbonation preferred by most people. • Refrigerating soft drinks, measuring their temperatures, and taste testing to determine temperature preferred by most people. • Experimenting with different types of flavors (syrup, dry, soda) and sugars (white, brown, honey) to determine best-tasting types. • Substituting ingredients to produce a less expensive drink that tastes the same. • See also SOCIAL SCIENCE list: *Manipulating, Controlling Variables/Experimenting.*
Designing and Constructing Measuring Devices and Equipment	• Designing a measuring cup by placing graduated markings on a paper cup. • Constructing a simple balance to compare weights of various ingredients. • Constructing a soft drink stand to use when selling the drink.
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	• Inferring from taste tests, survey data, and computation of costs that the best-tasting drink is not the least expensive. • Inferring that more sugar will make a drink taste sweeter. • Hypothesizing that more (less) of a flavor ingredient will make a drink stronger (weaker) and finding that this is so.

Inferring/Predicting/Formulating, Testing Hypotheses/Modeling (cont.)	• Hypothesizing that more (less) water or carbonated water will make a drink weaker (stronger) and finding that this is so. • Hypothesizing that a drink can be duplicated if measurements are accurate; making a drink a second time and taste testing to test this prediction. • Predicting the number of soft drinks that will be sold, based on survey data. • Holding a mock soft drink sale in preparation for the actual sale. • Constructing a drink difference map to model differences in characteristics of drinks tested. • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Measuring/Collecting, Recording Data	• Measuring ingredients using cups, teaspoons and tablespoons while mixing various soft drinks. • Recording amounts of ingredients needed for various recipes, various amounts of drink. • Taste testing and recording test results for various soft drinks in order to choose best-tasting drink. • See also MATHEMATICS list: *Measuring.* • See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring.*
Organizing, Processing Data	• Ordering drinks according to amount of sweetness, amount of carbonation, and taste-test preferences in order to determine ingredients for best-tasting soft drink. • Listing (in order of popularity) taste-test results and costs of several new soft drinks to decide which drinks are best-tasting and cheapest. • Ordering the steps necessary to make and sell a soft drink in quantity according to the order in which they must be done (e.g., buy ingredients, mix drink, advertise sale, refrigerate drink, get containers, set up drink stand, etc.). • See also MATHEMATICS list: *Organizing Data.* • See also SOCIAL SCIENCE list: *Organizing, Processing Data.*
Analyzing, Interpreting Data	• Determining amounts and types of ingredients to be used in chosen drink based on taste tests and survey results.

Analyzing, Interpreting Data (cont.)

- Plotting amount of sugar vs. amount of water in drink recipes to determine best-tasting proportion of sugar to water.
- See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing; Maximum and Minimum Values.*
- See also SOCIAL SCIENCE list: *Analyzing, Interpreting Data.*

Communicating, Displaying Data

- Representing data collected on various ingredients and drinks on graphs and charts.
- See also MATHEMATICS list: *Graphing.*
- See also SOCIAL SCIENCE list: *Communicating, Displaying Data.*
- See also LANGUAGE ARTS list.

Generalizing/Applying Process to New Problems

- Applying skills acquired to produce another soft drink, to follow recipes for other items.
- Applying graphing and surveying skills to other problems in the school.
- Applying skills acquired in testing ingredients to work on Consumer Research challenge.
- See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

Areas of Study

Measurement

- Measuring ingredients for soft drink recipes using various units of volume, such as teaspoons, tablespoons, cups, pints, quarts, liters and milliliters.
- Measuring ingredients for soft drink recipes by weight, using a weighing scale.
- Measuring, using a ruler or meter stick, when constructing a soft drink stand.
- See also *Designing and Constructing Measuring Devices and Equipment.*
- See also MATHEMATICS list: *Measuring.*

Force

- Observing, when constructing drink stand, that force must be used to hammer nails into lumber and that the hammer increases the force exerted.

Weight	• Weighing ingredients to determine amounts needed to make large quantity of recipe.
Mechanical Work and Energy	• Observing that work is done and energy is expended while hammering nails, painting. • Observing that electrical energy is converted into the mechanical energy of saber saws, electric drills. • See also *Force*.
Solids, Liquids, and Gases	
States of Matter	• Observing that some ingredients are in liquid form and others are in solid form. • Noting that an ice cube melts in a warm room, and that the water will gradually disappear if left uncovered. • Observing that gases can be dissolved in liquids (carbonation). • Observing that a carbonated drink will lose its carbonation if it sits open for a time.
Properties of Matter	• Observing that liquids have no form of their own but take the shape of the container they are in. • Observing that the amount of liquid in a tall, thin glass does not change when poured into a short, fat glass. • Observing that different mixtures have different smells and tastes. • Observing that some ingredients taste good and others don't even though the overall combination may taste good. • Observing that different solid ingredients have different textures, densities, and colors. • Observing that some liquid ingredients flow more slowly than others (e.g., syrup vs. water). • Observing that sugar may dissolve completely in a drink and every sip of the drink will taste sweet. • Observing that dry ingredients can be mixed to make a drink powder. • Observing that dry and wet ingredients combine to form a liquid drink. • Observing that the individual weights of the wet and dry ingredients equal the weight of the ingredients when combined.

Properties of Matter (cont.)	• Observing that some substances dissolve easily in liquids while others do not dissolve at all. • Observing that fine powders dissolve easier (faster) than large lumps. • Observing that substances dissolve faster in liquids when stirred. • Observing that dry ingredients dissolve faster in a hot liquid than in a cold liquid (e.g., water).
Heat/Temperature	• Measuring changes in temperature of soft drinks being refrigerated using a thermometer. • Observing that dry ingredients dissolve more rapidly in a hot liquid than in a cold one. • Observing that the temperature of a drink affects its taste.
Light	• Observing that both wet and dry ingredients have different colors. • Observing that ingredients dissolved in a liquid (e.g., water) form solutions of different colors through which light can pass. • Observing that as more of an ingredient is dissolved in a liquid, the color of the resulting solution becomes darker and more pronounced. • Observing that some ingredients (e.g., sugar) dissolve completely in water to form a colorless solution.
Nutrition/Growth	• Determining the nutritional value of ingredients used in soft drinks. • Observing that some ingredients and drinks have more nutritional value than others.

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Process	
Observing/Describing/Classifying	• Observing and describing preferences of other students for popular soft drinks. • Observing and describing preferences of other students for flavor, sweetness, color, temperature, or carbonation of a soft drink. • Observing, describing, and classifying problems of students who are mixing drinks, such as insufficient ingredients, or equipment, sloppy work in measuring and recording recipes, cleanup problems, and wasted materials. • See also MATHEMATICS list: *Classifying/Categorizing.* • See also SCIENCE list: *Observing/Describing; Classifying.*
Identifying Problems, Variables	• Identifying problems that occur during mixing sessions. • Identifying age and sex as possible factors in flavor and sweetness preferences. • Identifying cost of soft drinks as a variable to be investigated to determine least expensive soft drink. • See also SCIENCE list: *Identifying Variables.*
Manipulating, Controlling Variables/Experimenting	• Determining a procedure for setup and cleanup of mixing sessions; making a checklist of ingredients and supplies needed to improve mixing sessions. • Conducting an opinion survey using a stratified sample. • Surveying different groups of people (students and adults, males and females) to determine differences in flavor and sweetness preferences. • Defining the cost of a soft drink as the sum of the costs of ingredients used to make a certain quantity of soft drink. • Conducting an opinion survey to determine price others are willing to pay for soft drink. • See also SCIENCE list: *Manipulating, Controlling Variables/Experimenting.*
Inferring/Predicting/Formulating, Testing Hypotheses	• Predicting that mixing sessions will result in more information and better drinks when they are organized. • Utilizing opinion surveys to determine flavor and sweetness to be used in mixing, to determine whether more than one flavor of drink should be made.

Inferring/Predicting/Formulating Testing Hypotheses (cont.)	• Predicting characteristics that a good soft drink should have, based on results of opinion survey. • Hypothesizing that a drink that satisfies most people will result in greater volume of sales of drink; comparing sales per day after drink has been modified according to survey results to sales before drink was modified. • Recommending a selling price for the soft drink on the basis of survey data and cost analysis of soft dri k. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses.*
Collecting, Recording Data/ Measuring	• Recording data from surveys on tally sheets or bar graphs. • Using a voting procedure to determine favorite new soft drink, to determine name for soft drink. • See also MATHEMATICS list: *Counting, Measuring.* • See also SCIENCE list: *Measuring/Collecting, Recording Data.*
Organizing, Processing Data	• Tallying survey data on preferences for flavors, sweetness, carbonation. • Ordering survey results to rank findings about best-tasting soft drink. • Preparing cost analyses of ingredients for soft drinks. • See also MATHEMATICS list: *Organizing Data.* • See also SCIENCE list: *Organizing, Processing Data.*
Analyzing, Interpreting Data	• Comparing survey results for students and adults, males and females on taste preferences. • Assessing predictability of larger sample of student preferences based on results from smaller sample of student preferences. • Evaluating the way that opinion surveys were administered, evaluating size and makeup of samples. • Determining cost and amount of ingredients needed to make large quantity of new soft drink. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing; Maximum and Minimum Values.* • See also SCIENCE list: *Analyzing, Interpreting Data.*
Communicating, Displaying Data	• Representing survey data on taste preferences on graphs and charts.

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Communicating, Displaying Data (cont.)	• See also MATHEMATICS list: *Graphing*. • See also SCIENCE list: *Communicating, Displaying Data*. • See also LANGUAGE ARTS list.
Generalizing/Applying Process to Daily Life	• Concluding that working together in a group gives faster, more accurate, and more imaginative results than working individually. • Applying skills acquired from small group work to group work on other projects and problems. • Gaining insight into the problems of creating and producing a soft drink. • See also SCIENCE list: *Generalizing/Applying Process to New Problems*.

Attitudes/Values

Accepting Responsibility for Actions and Results	• Making sure that various tasks (e.g., purchasing ingredients, setup and cleanup for mixing sessions) are done. • Scheduling time and personnel to mix drink for party or to work at soft drink sale.
Developing Interest and Involvement in Human Affairs	• Selling drink to others after students in other grades have expressed a desire to buy the soft drink. • Distributing copies of recipe at end of school year so that others can make the drink.
Recognizing the Importance of Individual and Group Contributions to Society	• Recognizing that serving the soft drink at the party and/or selling the soft drink helps others in the school as well as themselves.
Developing Inquisitiveness, Self-Reliance, and Initiative	• Conducting group discussions and mixing sessions with help from the teacher. • Discussing prices and quantities of ingredients needed for soft drink with various merchants. • Finding their own solutions to problems of accurate mixing and recording of soft drink, of setup and cleanup at mixing sessions.

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Recognizing the Values of Cooperation, Group Work, and Division of Labor	• Finding that work on mixing soft drinks progresses more rapidly and smoothly when they work in groups. • Finding that mixing progresses more smoothly when each person has a specific task such as gathering ingredients, measuring, recording recipes. • Eliminating needless overlap in work by buying ingredients needed by all groups at one time and placing them in a central location.
Understanding the Modes of Inquiry Used in the Sciences, Appreciating Their Power and Precision	• Using scientific modes of inquiry when mixing and taste-testing new soft drinks to solve the problem of producing a drink that will satisfy the most people at a reasonable price. • Convincing others through the use of supporting data (opinion survey) that a particular flavor should be used for the soft drink. • See MATHEMATICS and SCIENCE lists.
Respecting the Views, Thoughts, and Feelings of Others.	• Considering all suggestions for flavors, colors, amount of sugar in the new soft drink and assessing their merit. • Considering the opinions of others: conducting an opinion survey to determine taste preferences for drink.
Being Open to New Ideas and Information	• Considering other ways of doing various tasks during mixing sessions, during planning for party or sale. • Asking other people for opinions, ideas, and information on taste factors, ingredients for soft drinks.
Learning the Importance and Influence of Values in Decision Making	• Realizing that cost effectiveness alone is not a sufficient criterion for choosing a soft drink; taste preferences of others must also be considered. • Realizing that taste preferences reflect the values of each individual.

Areas of Study

Economics	• Using concepts and terms, for example, cost, profit, production cost, retail price, when mixing and selling a new soft drink in quantity. • Gaining experience in comparative shopping for ingredients, in record keeping, in analyzing costs of ingredients.

Economics (cont.)	• Assessing preferences of possible customers through surveys and questionnaires. • Analyzing variables affecting purchase of soft drink. • Investigating economics of production and marketing of soft drink. • Investigating costs of ingredients for soft drinks vs. use of ingredients and budget restrictions. • Assessing costs, benefits of inventory and record keeping, quantity purchasing, mass production, and quality control.
Political Science/Government Systems	• Investigating regulations and policies concerning sale of soft drink, use of brand-name ingredients in new soft drink. • Contacting school authorities for permission to sell soft drink.
Social Psychology/Individual and Group Behavior	• Using preference data in developing a soft drink that is appealing to most people. • Recognizing that a blindfold test is a more accurate test of taste preference than a test where the color of the drink can be seen. • Recognizing the need for leadership within small and large groups.
Sociology/Social Systems	• Making a soft drink that will satisfy the needs of others in the school or community as well as themselves. • Devising a system of working cooperatively in small and large groups. • Relating jobs done when mixing new soft drinks to jobs done at home. • Recognizing that there are many different social groups and that one person belongs to more than one social group.

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ACTIVITIES IN SOFT DRINK DESIGN UTILIZING LANGUAGE ARTS

Basic Skills

Reading: Literal Comprehension--Decoding Words, Sentences, and Paragraphs	• Decoding words, sentences, and paragraphs while reading opinion surveys, labels of ingredients for mixing directions, recipes for new soft drinks, rules and regulations affecting sale of soft drinks.
Reading: Critical Reading--Comprehending Meanings, Interpretation	• Obtaining factual information about ingredients for soft drinks. • Understanding what is read about ingredients. • Interpreting what is read, such as rules and regulations affecting sale of soft drinks.
Oral Language: Speaking	• Offering ideas, suggestions, and criticisms during class discussions on problems and proposed solutions, and during small group mixing sessions. • Reporting to class on mixing activities of small groups. • Responding to criticisms of mixing activities. • Using the telephone properly to obtain information on costs and availability of ingredients. • Conducting opinion surveys. • Using rules of grammar in speaking. • Communicating need for making a drink with certain characteristics, using data, charts, graphs.
Oral Language: Listening	• Listening to group reports on small group activities, to reports on characteristics needed for a good soft drink. • Conducting interviews and taste tests of students and teachers to determine best soft drink. • Following spoken directions.
Written Language: Spelling	• Using correct spelling when writing recipes, surveys.
Written Language: Grammar--Punctuation, Syntax, Usage	• Using rules of grammar when writing recipes, surveys.

Written Language: Composition	• Writing to communicate effectively. • writing down opinion survey, devising questions to elicit desired information; judging whether a question is relevant and whether its meaning is clear. • preparing write-ups of recipes and directions for making soft drinks.
Study Skills: Outlining/Organizing	• Taking notes on various ingredients, amounts used in mixing soft drinks. • Developing opinion surveys; ordering questions around central themes such as preferences for flavors, amounts of sweetness, carbonation, in soft drinks. • Planning data collection schemes for taste tests. • Planning presentations of results from taste tests, opinion surveys.
Study Skills: Using References and Resources	• Using the library to research information on rules and regulations affecting sale of soft drinks. • Using "How To" Cards for information on slope diagrams, opinion surveys, and conversion graphs. • Using various reference volumes to obtain conversion tables for measurements when performing cost analysis of ingredients.
Attitudes/Values	
Appreciating the Value of Expressing Ideas Through Speaking and Writing	• Finding that writing down recipes carefully is important if drinks are to be duplicated. • Finding that written results from an opinion survey are useful in determining taste factors.
Appreciating the Value of Written Resources	• Finding that certain desired information (conversion tables, rules and regulations affecting sale of soft drink) can be found in books and catalogs.
Developing an Interest in Reading and Writing	• Willingly looking up information to convert from one measurement to another. • Showing desire to write opinion survey.

Making Judgments Concerning What Is Read	• Deciding whether what is read (e.g., rules and regulations) is applicable to the problem. • Deciding how reliable the information obtained from reading is. • Deciding whether the written material (e.g., opinion survey) is appropriate, whether it says what it is upposed to say, whether it may need improvement.
Appreciating the Value of Different Forms of Writing, Different Forms of Communication	• Finding that recipes for new soft drinks should be written down so that they can be referred to at a later time. • Finding that an oral opinion survey of one classroom is effective but that a written opinion survey is more useful when surveying large numbers of people. • Finding that how information can best be conveyed is determined in part by the audience to whom it is directed. • Finding that certain information can be conveyed best by preparing graphs and charts, making an announcement, writing notes, etc. • Finding that spoken instructions are sometimes better than written instructions, and vice versa.