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AUTHOR Sampson, Sue Scott
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ABSTRACT

This Unified Sciences and Mathematics for Elementary Schools (USMES) unit challenges students to find ways to improve or organize a Design Lab. 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 problems, and a hypothetical account of fourth/fifth-grade class activities. Section III provides documented events of actual class activities from grades 2, 4, and 5. 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 design activities. (JN)

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Contributors

This Edition of Design Lab Design:

Written and edited by Sue Scott Sampson
Supervising editors: Betty M. Beck, L. Ray Brady, Jr.
Production work: L. Ray Brady, Jr., Martha Allegro, Nancy C. Brady
Cover and title page by L. Ray Brady, Jr.

University Content and Curriculum Specialist

Charles D. Donahoe, USMES Staff Design Lab Coordinator

Classroom Teachers

Yolanda Benjamin, Charleston, SC
Barbara Briggs, Plainfield, NJ
Sally Callahan-Chebator, Arlington, MA
Phyllis Viall Cooper, Cotuit, MA
Carol Hardy, Athens, GA
Margaret Hartzler, Boulder, CO
Alice Hunt, Ganado, AZ
Robert Lindley, Houston, TX
Laura Lyon, Boulder, CO
Michael McCabe, Arlington, MA
Donald Nelson, Roswell, GA
Marie Salah, Watertown, MA
Janet Sitter, Howell, MI
David Trunnell, Iowa City, IA
Gregory Weatherspoon, Lansing, MI

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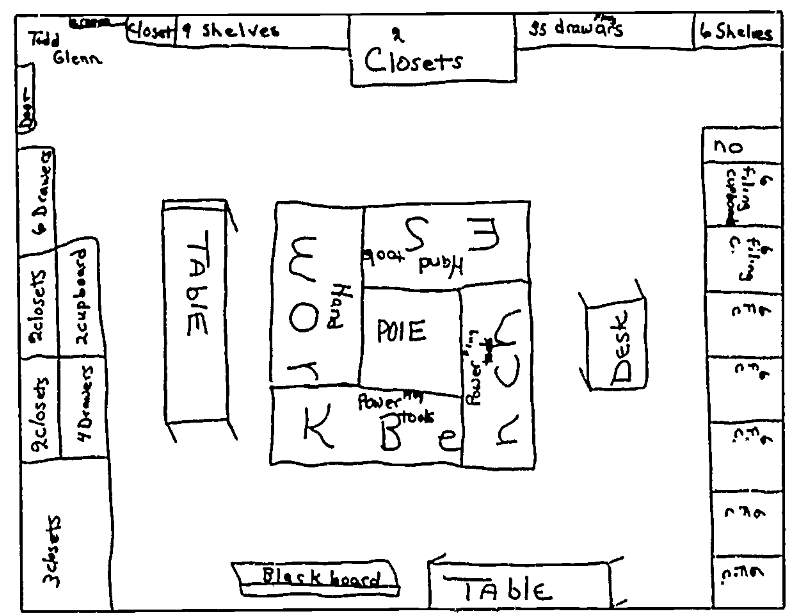
This book is a resource developed by the USMES Project: Earle L. Lomon, Project Director, Betty M. Beck, Associate Director for Development, Thomas L. Brown, Associate Director for Utilization Studies, Quinton E. Baker, Associate Director for Administration.

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

Design Lab Design

Second Edition



Education Development Center, Inc.
55 Chapel Street
Newton, MA 02160

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CHALLENGE: FIND WAYS TO IMPROVE OR SET UP THE DESIGN LAB FOR THE BENEFIT OF THOSE WHO USE IT.

Table of Contents

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

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.

*   *   *   *   *

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.

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.

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

*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 ritical 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 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.

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 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. New Area of Learning--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

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.

B. General Papers on Design Lab Design

1. OVERVIEW OF ACTIVITIES

Challenge:

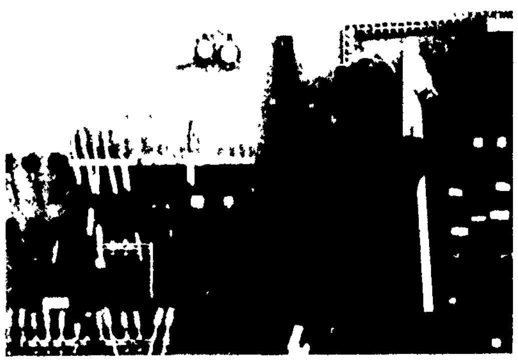
Find ways to improve or set up the Design Lab for the benefit of those who use it.

Possible Class Challenges:

Find ways to make the Design Lab better.

What is the best way to set up a Design Lab in our room?

How can we improve the Design Lab for use by younger children?



Whatever form a Design Lab takes--a portable tool cart, an in-class lab, or a well-stocked or threadbare Design Lab room--it may not be offering the range and quality of services possible. During work in the lab, a teacher may notice students faltering as a result of insufficient tools or materials, overcrowding, or awkward table heights. The students themselves may complain of these and other difficulties; they may store projects in the lab only to find them destroyed the next day, they may grow frustrated when forced to wait too long to obtain adult supervision for using a power tool, or they may become annoyed upon finding a messy lab. The Design Lab Design challenge may arise during or immediately following another USMES unit, at the start of the year, or perhaps as an outgrowth of a non-USMES topic during which students have worked in the Design Lab.

Several Design Lab problems may emerge during the initial class discussion, and the children may want to survey other students for their opinions before assigning priorities to the problems to be tackled. Observations of other classes in the lab and interviews with the Design Lab manager may provide further insight into lab problems. After analyzing the survey results and other data, the children may form groups to work on resolving the most critical problems.

Each group begins by deciding on a plan of action which usually involves some form of data collection. Children concerned with the lab inventory may make an updated list of tools and materials on hand and then survey other lab users to find what additional items are needed. They might also conduct tests on a representative sample of students to discover the most convenient sizes of tools. In preparation for purchasing lab materials, the group may collect data on tool prices, sizes, and guarantees from catalogs and local stores.

A group working on setting up or improving the layout of the Design Lab may make traffic-flow diagrams based on their observations. They may choose to measure the dimensions of the room and the furniture to make a scale layout for experimenting with various arrangements. If additional workbenches or tables are to be constructed, the group can take measurements of other students to ensure proper heights.

Data collection may take different forms in other groups.

To resolve a noise problem, a group may need to measure noise levels and try out various acoustical materials. Another group researching information on fire and accident prevention may write to fire departments, safety councils, and other appropriate organizations. A group trying to improve the use of the lab may need to collect data on class schedules and the number of students using the lab at different times.

Children may depict their data on graphs or charts and analyze these during class discussions. After interpreting the information, they can propose solutions to the problems and talk about the pros and cons of suggested improvements. Several sessions may be spent working out the final plans for changes.

Before implementing any final solutions, the class may first have to obtain approval from the principal, school board, or PTA, thus affording the students an opportunity to prepare a unified presentation of their findings and recommendations. Once approval has been obtained, the children can carry out their changes.

Burglar alarms may be constructed and installed, safety posters made and displayed, furniture rearranged, materials reorganized, and new lab procedures put into effect. Fund-raising events, planned and run by the students, may cover the cost of new lab supplies and tools. A scrounging campaign might also produce needed materials and cut down the expenses.

To measure the success of their improvements, the class may conduct attitude surveys to find out how students, teachers, and lab helpers feel about the changes. Additional measurements and observations in the lab can help determine whether modifications are needed.

Some aspects of the students' program may require continued effort. Children may keep inventory records up to date; they may act as an orientation staff whenever classes use the lab for the first time; or they may periodically devote some time to helping younger students use tools and materials effectively and safely.

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: wheras 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 Design Lab Design children also learn and practice graphing, measuring, working with decimals, and dividing. Although dividing seems necessary to compare fractions or ratios, primary children can make comparisons graphically; sets of data can also be compared graphically or by subtracting medians (half-way values). Furthermore, instead of using division to make scale drawings, younger children can convert their measurements to spaces on graph paper. Division may be introduced at the proper grade level during calculation of percentages, averages, or unit costs.

2. CLASSROOM STRATEGY FOR DESIGN LAB DESIGN

Design Lab Design revolves around a challenge--a statement that says, "Solve this problem." Its success or failure in the classroom 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 Design Lab Design challenge--"Find ways to improve or set up the Design Lab for the benefit of those who use it"--is general enough to apply to many situations. Students in different classes define and reword the challenge to fit their own particular Design Lab problems and thus arrive at a specific class challenge. For example, some classes have stated the challenge in terms of setting up an in-class lab or converting an unused room into a Design Lab for the school, while others have worked on more specific problems in an existing Design Lab, such as increasing the tool inventory.

The Process of Introducing the Challenge

Given that a 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 challenge are helpful.

One such technique is to turn a discussion of some recent event towards a Design Lab Design challenge. For example, students who have been using an in-class or mobile Design Lab may learn that a room has become available for a permanent Design Lab. A teacher may notice that children are experiencing problems in the lab (for USMES or non-USMES work) or may hear their complaints about lab scheduling, rules, working space, or supply of materials. A class discussion of these problems may lead to a Design Lab Design challenge to improve the situation.

During the first year of working on USMES challenges, students in one school that had no Design Lab carried out their construction activities in their classrooms and in an outdoor breezeway area. When a large custodian's room became available the next year, a sixth-grade class agreed to take on the challenge of converting the room into a permanent Design Lab for the school. Students formed groups to investigate room arrangement, decorations, new supplies, tool storage and safety, and lighting.

Complaints by several sixth-graders about problems in the Design Lab led to a general class discussion. Together the class listed various lab problems they had encountered; for example, wasted materials, not enough lab time, disorganized tools, students not following rules, student helpers playing and causing trouble instead of working. Although it was near the end of the school year, the students felt that some problems were so severe that they should be corrected as quickly as possible. Consequently, the class formed groups to work on installing a pegboard rack to organize and store tools, maintaining an inventory list, and monitoring lab activities to show that certain problems were common to all classes using the lab.

In some classes a Design Lab Design challenge may arise from specific investigations carried out during another USMES unit. For example, during work on Consumer Research, children may test Design Lab supplies, such as batteries, to determine whether the school has obtained the "best buys." After completing this work, the children may want to improve other aspects of the lab. Another class, working on Designing for Human Proportions, may investigate tool sizes or heights of workbenches and afterwards try to solve other Design Lab problems.

When students encounter Design Lab problems during their work on another USMES unit, several courses of action may be taken. For example, one group of students may begin work on the Design Lab Design challenge while the rest of the class continues with the first challenge. Alternatively, the entire class may choose to suspend temporarily their investigations on the first challenge while they resolve the Design Lab problems. However, there should be at least ten to twelve students working on any one challenge; otherwise, the children's work may become fragmented or superficial or break down completely.

One class of fourth graders wanted to construct weather instruments for their investigations on Weather Predictions. As their school had no Design Lab, the students decided to set up an in-class lab. After scrounging materials and tools, they constructed two workbenches from plywood and studs and rearranged the classroom to accommodate their lab space. The work was completed within a month, and the class again turned their attention to the Weather Predictions challenge.

A Design Lab Design challenge may also evolve from a discussion of a specific topic being studied by the class. A class studying a science topic, such as heat or light, may become interested in improving physical conditions in the Design Lab.

Sometimes the discussion of a broad problem may encompass the challenges of several related units. For example, a discussion of problems at school could lead to Design Lab Design, Classroom Design, Classroom Management, Eating in School, Orientation, Play Area Design and Use, or School Supplies, depending on which specific problems the children identify.

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 a Design Lab Design challenge 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 teacher in one intermediate class introduced the Design Lab Design challenge at the beginning of the year by stating that the teachers had suggested that the Design Lab needed improvement. The students agreed to look into the problem and began listing suggestions for changes. They visited the lab and made a few alterations, such as moving some tools, but by the end of the second session, about half the class had begun to lose interest. Many students felt that they had completed their work; they had listed problems and possible remedies. The challenge was issued in such a way that, rather than working to solve their own lab problems, the students were trying to find solutions for teachers. After several sessions of random activity, the majority of the class became enthusiastic about another school problem raised by the students and only three or four children continued to work on the Design Lab Design challenge.

Although children do not need USMES experience before working on Design Lab Design, their investigations will proceed more smoothly if they have had at least some experience with tools, for example, in the school shop. Otherwise, they may lack an understanding of the role of the Design Lab and the types of activities that take place there. Without a purpose for setting up or improving the lab, the children may work poorly and make arbitrary rather than thoughtful decisions. To compensate for what many seem to be a lack of motivation in the childr , the teacher may become more directive, perhaps even assigning activities to continue the work. Although the teacher may see how these activities relate to an overall goal, the children may not; rather than learning to solve their own real problems, the students are merely completing another school assignment.

Initial Work on the Challenge

Once a class has decided to work on a Design Lab 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 difficulty remembering exactly where they were in their investigations and their momentum diminishes.

During the initial session, children often list Design Lab problems; and the list usually is long. By combining similar complaints and by choosing one or two major problems to work on first, the class can arrive at a manageable challenge. If the students try to tackle too many problems at once, their investigations will be superficial.

Once they have agreed upon which problem in the Design Lab deserves their immediate attention, the children suggest approaches to solving it. Next, they categorize their suggestions, list the tasks necessary to carry out their ideas, and set priorities for these tasks.

In one school where USMES was being introduced into the curriculum, an intermediate-level class was issued a challenge at the beginning of the year to set up a Design Lab for the entire school. With no clear understanding of the Design Lab concept and no immediate purpose for setting up a lab, the children set no priorities for their tasks. Instead, they spent almost a month working in groups, each trying to devise an inventory and price list. There was a great deal of overlap in the groups' efforts; heated arguments often erupted and no decisions were reached. Finally one group approached the teacher with what they termed "important questions"--where would the lab be located, how much space would they have, who would use the lab? A class discussion was held, and when the other students realized their misdirection, selection of tools was postponed until these other vital issues were resolved.

Often students form groups to work on the tasks they have listed. However, if too many groups are formed, work on the challenge can become fragmented. The teacher 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 children work on a Design Lab Design challenge, their attention should, from time to time, be refocused on that challenge so that they do not lose sight of their overall goal. 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 solutions 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 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 that it will be easier to try out different lab arrangements on a scale drawing rather than moving the furniture, the teacher might ask, "How can you find out, without moving all the furniture, whether we will have more working space with a new arrangement?" Examples of other nondirective, thought-provoking questions are given 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. 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 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. If the children need to collect data in other classrooms, the teacher can help with scheduling and supervision. For a Design Lab Design challenge, a class will, of course, need access to the Design Lab to conduct observations and measurements, carry out tests the children devise, and implement their solutions.

Culminating Activities

Student investigations generally continue until the children have agreed upon and implemented some solution to

the problem. They may increase the lab inventory by conducting a scrounging campaign or by a fund-raising project to purchase materials; they may construct tables or workbenches or put up safety posters; they might rearrange the lab layout or set up a new schedule for lab use.

After the students have implemented their solution, they evaluate the effects of their changes by observing, by measuring, by conducting attitude surveys, or by having a class discussion. Children might observe whether the tools are easier to find and whether overcrowding has been alleviated; they might measure sound levels to see whether the noise has been reduced; they might devise and distribute a questionnaire to find out whether lab users approve of the changes; or they might simply discuss whether they have met their challenge. Through their work on Design Lab Design, the class may become involved in related USMES units such as Protecting Property, Consumer Research, School Rules, Designing for Human Proportions, or Mass Communications.

3. USE OF DESIGN LAB DESIGN IN THE PRIMARY GRADES

Young children are usually enthusiastic about working in the Design Lab. They are eager to learn how to use the different tools and to see their own ideas and plans take shape for an animal cage, a Tri-Wall table, a soft drink stand, or perhaps an advertising poster.

After some experience in working in the lab, primary classes may find that changes are needed--no glue for the glue gun, the hammer is too large, things aren't put away, no signs about what to do for a fire drill. These and other suggestions may be offered in response to a teacher's questions, "What did you like about working in the Design Lab? How could you make it a better place to work?" A visit to the lab can often refresh the student's memories, and additional problems may be noted.

One or more of the problems that the children point out may form the basis of their Design Lab Design challenge. To choose which one to work on first, the class usually votes. If the list is a long one, each child can have two, or perhaps three, votes. The children will work on the problems with the most votes.

Several groups may form to work on different aspects of the challenge or to work on two or three different problems. For example, one second-grade class divided into two groups to resolve two Design Lab problems--lack of posters with safety reminders and lack of smaller-sized tools. When primary students work on more than one problem, some teachers allow only one group to work at a time. Other teachers prefer to have the entire class work together, at least at first.

The children may devise and conduct simple surveys to find out, for example, what additional tools and supplies are needed by other classes or whether large tools present a problem for other primary children. A simple checklist, with space for a yes or no vote, is easy for young children to understand and to tally.

Survey data may be tallied by making tally marks in appropriately labeled columns. The children may also tally the data directly by stacking blocks onto a bar graph, thus making a visible picture that will help them interpret the results more easily. Either technique, however, simplifies the work and lessens the chance that the data will overwhelm the children.

Students trying to improve the arrangement of the lab may find that a model layout helps them visualize and test their ideas. Measurements of the room can be taken with a tape measure or a folding rule, or more simply, by counting tiles on the floor; dimensions are then converted to spaces on graph paper or a grid. Scale cutouts of lab furniture allow different arrangements to be tried without actually moving the furniture.

If a primary class wants to calculate an average (e.g., the average waist-to-floor height of primary students), the children can find the median, which is easier to find and often a better number to use than the average. By ordering the data from smallest to largest and counting to find the middle number, no division is necessary.

Comparing ratios or percentages can also be done without dividing. Children using comparative shopping to buy lab materials, such as glue, can make a slope diagram to represent the cost per ounce for different brands or sizes. The least steep line indicates the cheapest buy.

Primary students are even capable of making a relatively sophisticated three-dimensional graph. For example, if the children measure sound in different parts of the lab, they can stack blocks on their scale drawing of the room. In such a graph, the two dimensions of the scale drawing indicate position in the room and the third dimension shown by the blocks represents the sound level.

Language arts skills are learned and reinforced during work on any USMES unit. Oral communication is practiced during class and group discussions. Writing skills are used for taking notes and devising surveys. For a Design Lab Design challenge, children may write rules or make safety posters, and they may write letters requesting information from safety organizations, local stores, or other schools with Design Labs.

Because the attention span of younger children is shorter than that of older students, teachers of primary classes find that short but frequent USMES sessions produce the best results. Each session may start with a class discussion which helps the class focus on their overall goal of improving the lab. Such discussions, combined with group reporting, gives the children a chance to help each other and to provide input into decision making and planning.

After changes have been made in the lab, the children may want to find out if they've really improved the situation. Through a discussion, an opinion survey, or additional measurements, they can evaluate how effective their change has been and whether modifications are needed. When the class feels satisfied that they have reached the best solution, they may review their list of Design Lab problems and begin work on another one.

During the activities mentioned here, primary children learn and practice, within a real context, skills and concepts in mathematics, science, social science, and language arts. They also improve their interpersonal relationships, develop problem-solving abilities, and become confident that they can have a positive effect on the world in which they live.

4. FLOW CHART

The following flow charts present some of the student activities--discussions, observations, calculations, constructions--that may occur during work on the Design Lab 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 Design Lab Design problem.

Challenge: Find ways to improve or set up the Design Lab for the benefit of those who use it.*

Optional Preliminary Activities:

Another USMES Unit

Construction activities for non-USMES project

Science topic on sound

Possible Student Activities:

Class Discussion: How do you feel about working in the Design Lab? Do you have any problems working in the lab? How could you improve the lab? Are there enough tools and materials? Can you easily find what you need and use it when you want? Are there ways to make the lab safer? Does the lab serve everyone's needs?

Data Collection: Observing students working in the lab and using tools.

Data Collection: Designing and conducting survey of students (and/or teachers) to find out their opinions on Design Lab problems or needs.

Data Representation: Preparing bar graphs, line graphs, and histograms.

Data Representation: Tallying survey results.

Class Discussion: Interpretation of graphs. Reporting on observations. Which problems seem to be the most critical? Can we do anything to help eliminate them? How can we group problems so they will be easier to work on? Assigning priorities to problems, deciding how many and which ones to investigate. Formation of groups.

Safety. (See Flow Chart A.)

Improving the Use of the Lab. (See Flow Chart B.)

Furniture and Layout. (See Flow Chart C.)

Inventory. (See Flow Chart D.)

Noise. (See Flow Chart E.)

*This flow chart applies to an in-class Design Lab, a portable Design Lab (e.g., a mobile tool carrier), and a Design Lab room.

(When class is working on more than one aspect)

Class Discussion: Presentation of group reports, proposed changes. Evaluation of data and suggested changes. Discussion of logistics, financing. Obtaining approval of changes.

Implementation of approved changes.

Class Discussion: Have our changes improved the Design Lab? How have they made a difference? How can we find out how much difference they have made?

Data Collection: Observing student behavior and reactions in the lab; measuring how long it takes to find a tool; measuring sound-levels; checking records on inventory, accidents, lab use, etc.

Data Collection: Opinion survey to find out how lab users feel about changes.

Data Representation: Tallying results. Preparing bar graphs, line charts, etc.

Class Discussion: Interpretation of data and evaluation of changes. What revisions or modifications need to be made? What other changes can we make to improve Design Lab use?

Optional Follow-Up Activities:

Other USMES Units:

- *Classroom Design*
- *Consumer Research*
- *Protecting Property*
- *Eating in School*
- *Classroom Management*
- *School Rules*
- *Manufacturing*
- *Mass Communications*
- *Play Area Design and Use*
- *Designing for Human Proportions*

FLOW CHART A

Safety

Class Discussion: How can we determine the most serious hazards in the Design Lab?

Data Collection: Observing students in Design Lab. Recording number, types and causes of accidents and number of incidents of "unsafe" behavior.

Data Collection: Designing accident report forms to be filled out by lab manager, teachers, or students.

Data Representation: Compiling data on accidents and unsafe behavior. Preparing charts, bar graphs, histograms, scatter graphs. Representing several sets of data on one graph.

Class Discussion: Reporting results to classmates. Discussing suggestions for action. Making recommendations to other groups on safety improvements.

Gathering information from school nurse, Design Lab manager, and safety-related organizations, emergency procedures and accident prevention.

Sorting information that is applicable to the challenge.

Informing lab users on fire drill procedure and exiting from lab.

Working with lab manager or teachers to prepare presentations on how to use lab and tools safely and efficiently.

Adapting presentations for use with primary classes.

Assembling a first-aid kit or restocking emergency supplies.

Drafting rules on safe behavior in the lab and safe use of tools.

Modifying existing tools or recommending purchase of other types of tools.

Communicating recommendations to tool companies or safety organizations.

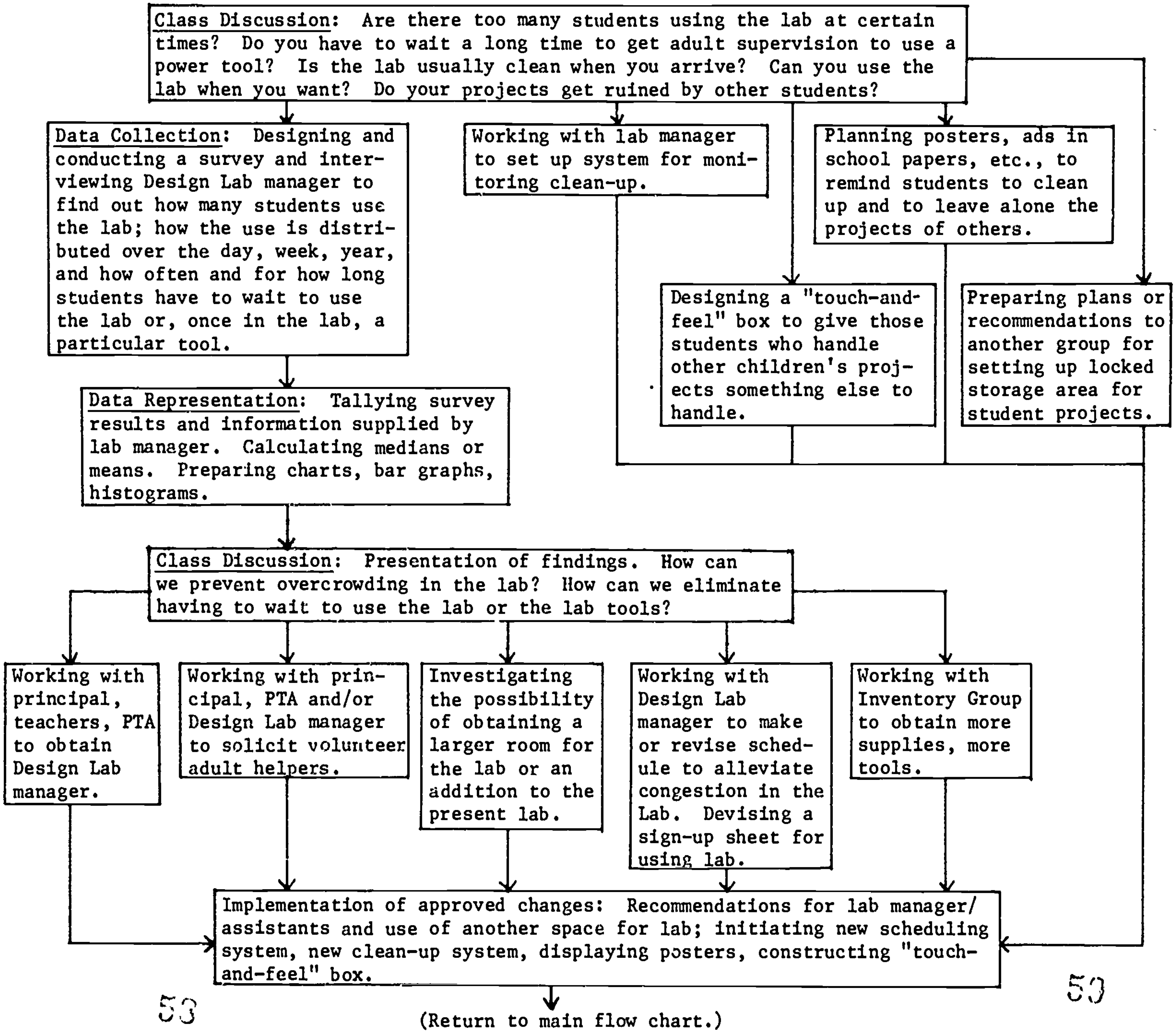
Reporting to other groups whose work may be affected by gathered information or by plans of Safety Group.

Implementation of proposed changes: Preparing and displaying posters for Design Lab. Making presentations and writing intercom announcements and/or articles for school newspaper to disseminate safety information to lab users.

(Return to main flow chart.)

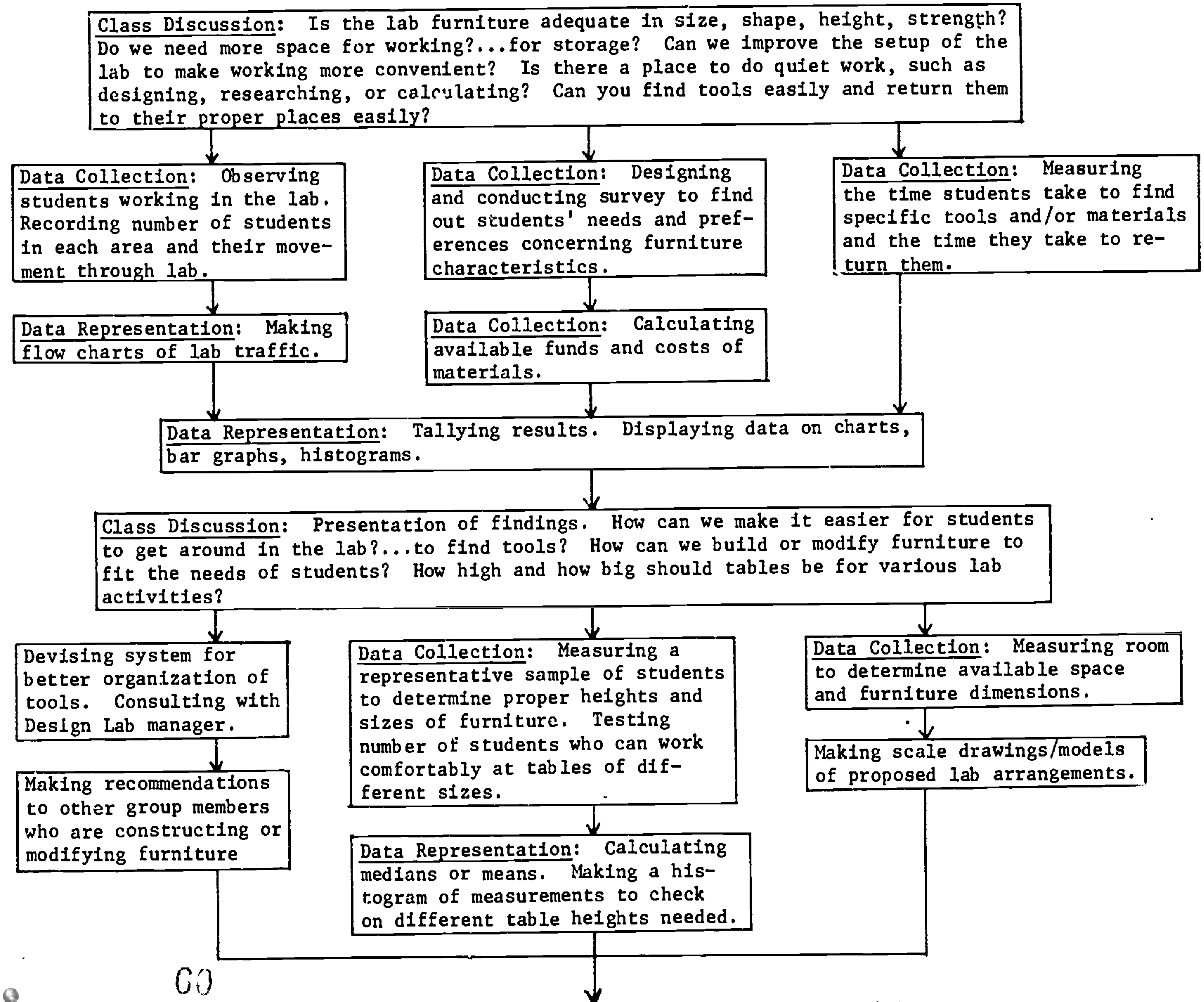
FLOW CHART B

Improving the Use of the Lab



FLOW CHART C

Furniture and Layout



Data Collection: Gathering information on fire regulations. Working with Safety Group.

Class Discussion: Interpretation of data. Presentation of group reports, plans. Discussion of finances. Deciding on proposed changes.

Data Collection: Additional measurements, graphing, analysis, surveys.

Planning and making posters to inform students where tools are and to remind students to put tools back in their proper place.

Preparing plans for constructing new furniture or modifying existing furniture.

Devise layout for lab.

Implementation of approved changes: institution of new organization system for tools; hanging posters; constructing or modifying furniture; rearrangement of furniture in lab.

(Return to main flow chart.)

FLOW CHART D

Inventory

Class Discussion: Do we have sufficient tools?...materials? Are materials and tools lost?...stolen?...broken?...wasted? Do other students need additional supplies?

Preparing a present inventory list and a start-of-year list.

Data Collection: Designing and conducting a survey of students and/or teachers to find out tools and materials most frequently used, additions needed, new types and sizes of tools to be added.

Data Collection: Interviewing Design Lab manager to find out extent of theft, waste, breakage, and use of tools and materials.

Data Collection: Testing primary-grade children to see which sizes of tools they use most conveniently.

Data Representation: Tallying data. Preparation of charts, bar graphs.

Class Discussion: Presentation and interpretation of data. How can we obtain more tools and materials? Which types and sizes of tools should we get? How can we better preserve our inventory?

Devising program for scrounging materials and tools and/or soliciting donations.

Devising a fund-raising campaign.

Reviewing survey data and information obtained from Safety Group to decide which items to buy.

Examining catalogs and using comparative shopping to determine where to buy items and how much each will cost. Constructing slope diagrams to show price per unit.

Planning a theft-prevention campaign. Making plans for or recommendations to another group for a locked storage area or a burglar alarm system.

Working with Furniture and Layout Group to set up better organization of supplies and tools.

Working with lab manager to devise and maintain an inventory sheet.

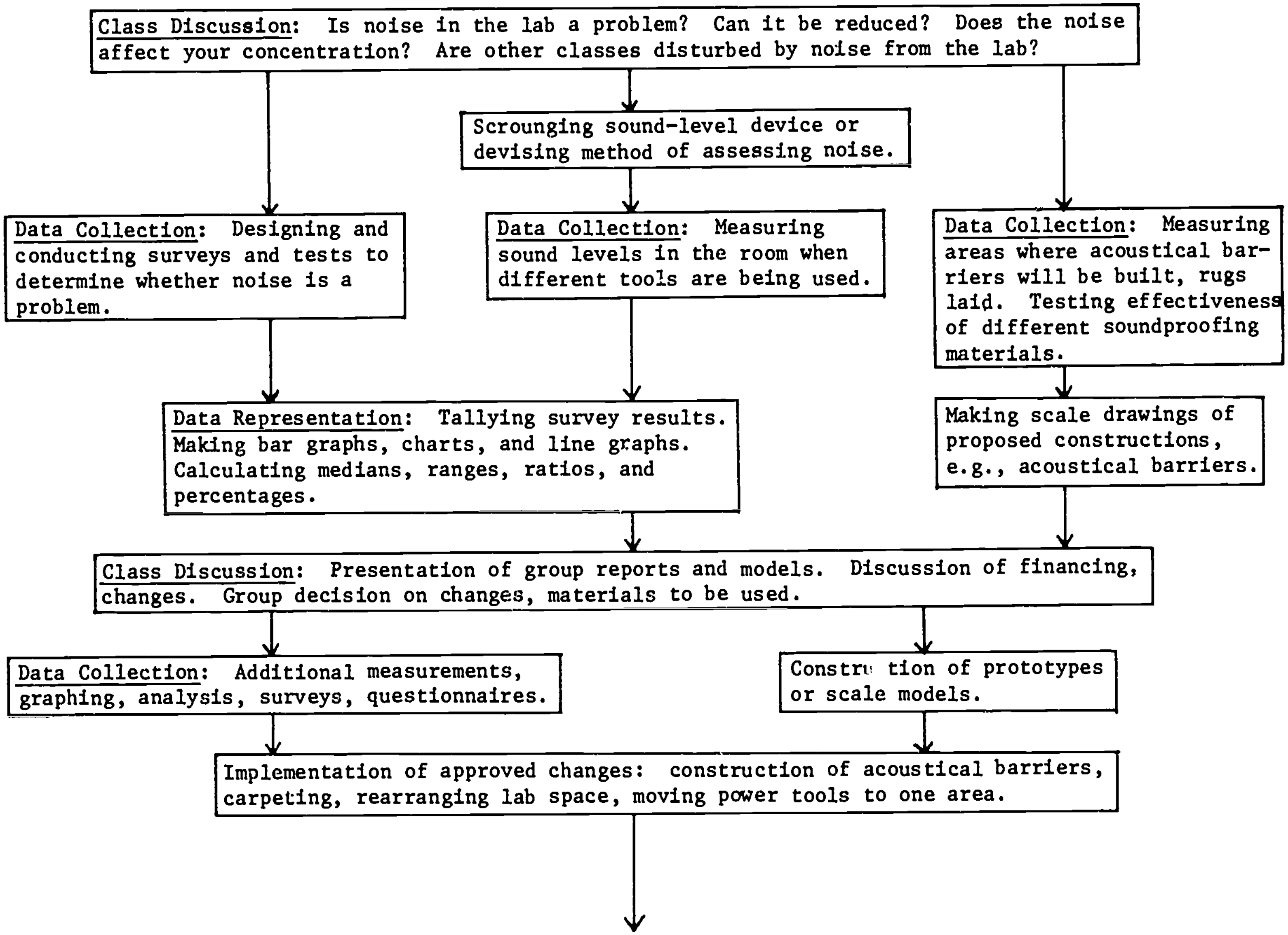
Devising a program (with lab manager) aimed at having students maintain equipment better. Designing "How To" Cards about properly using, caring for, and cleaning equipment and designing reminder posters. Organizing USMES "How To" Cards for accessibility to all lab users.

Implementation of approved changes: Purchasing tools, supplies; organizing tools; maintaining inventory control; constructing burglar alarm; instituting program for maintenance of equipment.

(Return to main flow chart.)

FLOW CHART E

Noise



(Return to main flow chart.)

5. A COMPOSITE LOG*

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

Mass production of geoboards, part of their work on the Manufacturing unit, takes more time than students in a combination fourth/fifth-grade class have anticipated. Because their school has only a mobile tool cart and no separate Design Lab room, construction activities must take place in the classroom. Before and after each lab session, the children must rearrange the desks and make other adjustments for working with tools.

While working on the Weather Predictions challenge, fourth graders in Cotuit, Massachusetts, investigated making their classroom suitable for working with tools. Because their desks "jumped around" or were too small, the children initially hammered on the floor and sawed lumber by bridging the wood across two desks. When these methods still proved unsatisfactory, the children designed and built two sturdy workbenches and set up an in-class Design Lab. (See log by Phyllis Viall Cooper.)

Although they have adapted to working in the classroom to produce the initial quantity of geoboards, the students continue to feel hampered by the limited facilities. Therefore, when the teacher announces that the school has made a room available for a Design Lab, the students are delighted. They become even more enthusiastic when the teacher introduces the challenge: Set up a Design Lab that will best serve those who use it.

Students in a sixth-grade class in Arlington, Massachusetts, ran into Design Lab problems with staffing and organization during their work on Classroom Design. Because most of their work on Classroom Design was completed, the children considered it a worthwhile venture to become involved in Design Lab Design and work for the remainder of the year on improving the situation in their lab. (From log by Michael McCabe.)

*Written by USMES staff

"Can we look at the room now?" one student asks excitedly, and when the teacher agrees, another student suggests that each child bring a pencil and some paper to make notes.

A combination third/fourth-grade class in Sterling Heights, Michigan, worked on setting up a Design Lab in new quarters--less spacious than the lab room they had at the time. During their first session, the children, at their own request, went to the room to measure the dimensions. (From log by Marjorie Girardot.)

The class proceeds to the future quarters of the lab where the children scurry about, count the number of shelves in each of two cabinets, pace off distances, do make-believe hammering and sawing at student desks in the room, make notes, and confer with one another. When their teacher sees that they have completed their observations, the children return to their classroom to compile and discuss their ideas.

"It's a big room," exclaims one student, and the volunteer recorder writes down the remark. Other comments include the following:

- There are no workbenches.
- The floor is dirty.
- The metal cabinets will be useful for storing tools.
- There's no sign on the door.
- There's no closet to store big pieces of Tri-Wall or wood.
- The room is forty-seven paces long and thirty-four paces wide.
- There are three windows.

At the beginning of the school year, sixth graders in Iowa City, Iowa, discussed their past experiences using the Design Lab and agreed that improvements were needed. To refresh their memories, they visited the lab to investigate six problem areas they had noted. After thoroughly examining the lab room, the students returned to their classroom and revised their list of needed improvements to include the following ideas: (1) get equipment, (2) make rules, (3) make a reserve place for finished and unfinished *projects, (4) get donations and scraps, (5) rearrange entire room, (6) sort materials and supplies--find a place for everything, (7) move old things out of Design Lab. (From log by David Trunnell.)*

After the children discuss their observations, the teacher asks whether they have enough information to go ahead and set up the Design Lab. A few students say yes, but one child points out that they know almost nothing about the wants and needs of other classes that will also use the lab.

"We should also write down our troubles with working in our classroom," suggests another student. The class decides to heed both pieces of advice, and as the session ends, all agree to "do some thinking" about problems they've had with their in-class lab and about ways to find out the opinions of others.

At the outset of the next session, the children list the following problems that they've had working with tools in their classroom:

1. Desks aren't sturdy enough.
2. It takes a long time to find the tool you want.
3. We need more hammers and saws.
4. We need more types of tools.
5. Glue gun can burn people.
6. Glue gun can ruin clothing.
7. Desks aren't large enough.
8. Desks are too high for sawing.
9. People leave power tools plugged in.
10. We can't always get the tool cart when we need it.

One child mentions that there may be additional problems when other classes use the lab. He gives some examples and then other children join in, adding the following issues to the list:

11. Everyone may not know safety rules.
12. Even if they all know the rules, they may not follow them.
13. Who will keep the lab clean?
14. The lab may become too crowded.
15. There may not be enough materials for everyone.
16. People may not know where to find each tool.
17. People may steal tools.
18. People may not know which exit to use during a fire drill.
19. Other classes may need different materials.

"Are the younger kids going to use the lab too?" inquires one child. After the teacher responds affirmatively, the student mentions that younger children may cause special problems.

"What things should we consider in designing the lab so younger children will be able to use it conveniently?" the teacher asks, and the children suggest the following:

1. They will need smaller tools.
2. There should be some small tables.
3. They may need special help on how to use the tools.

After each has copied the lists of problems, the teacher reminds the students about their decision to gather information from other lab users. One student suggests taking a survey but then realizes that tallying might prove difficult if the survey asks about the kinds of problems that people have using the lab. "There will be too many different answer," she says. Another child suggests devising questions that are more specific, but the class agrees that this idea defeats the purpose of finding out about problems that the class has not thought of.

In Boulder, Colorado, a class of fifth graders felt they should consult other lab users in the school before making any changes in the Design Lab. The children devised a questionnaire, listing eight issues that they considered possible lab problems and asked other classes to check the ones that they thought were problems. After tallying the results, the children made bar graphs of the data and assigned priorities to the problems according to the number of votes each received. (See log by Margaret Hartzler.)

The children finally go along with one student's recommendation to watch other classes' working during lab sessions. Another child notes, "We can talk to the teachers in case they have any ideas." Discussion then centers on what to observe and to ask about, and the children list the following items:

1. which tools are used
2. problems using tools

3. problems using tables and cabinets
4. finding and returning tools and materials
5. safety

Also, the children decide to visit classes to interview teachers and students about lab problems they have encountered and additional materials and tools they need or may need soon.

Another fifth-grade class in Boulder, Colorado, agreed that because they were primarily interested in serving the needs of the most frequent Design Lab users, they would identify those people by conducting a preliminary survey of teachers to find out how often their classes used the lab. Based on those results, a se' ..d survey was administered only to lab users, who were asked about their needs for additional tools and supplies. The fifth graders then separated their second survey results into those who had used the lab three or more times and those who had used it less frequently so that they could give greater weight to the opinions of the first group. (From log by Laura Lyon.)

Notes to teachers, requesting appointments, seems the most practical means for arranging interview times. After the class drafts and revises a form, one volunteer prepares a ditto and another duplicates and distributes the letters to teacher mailboxes. The note includes the children's wish to observe lab sessions. To maximize efficiency, the children decide that they will go in pairs to conduct their interviews and make their observations, and each pair will then report to the class.

Within a week, visitations have begun, and several days after that, the children assemble to discuss the reports. Most of the presentations reaffirm what the children have already discussed, but some new issues emerge:

- not enough space between work stations
- extension cords for power tools getting in people's way
- fooling around, wasting time

Once the children have added these items to their lists of things to be considered, they discuss how they will proceed in meeting their challenge. The teacher asks whether the class has any ideas about how to deal with all the issues, and the children suggest forming groups and giving each group "a bunch of items to work on."

"How will you decide which groups will work on which problems?" asks the teacher.

One child responds, "Some of the problems are a lot like each other." In support, another child points out that the two problems involving the glue gun are similar enough to be assigned to one group. Sorting and categorizing the problems take up the remainder of the session, but the children finally organize the groups and their responsibilities as follows:

1. Safety
   - find out about fire regulations
   - find out about hazards--fire, tools
   - find out about what to do in case of accidents or fire
   - give advice to other groups
   - help younger kids
   - educate lab users about safety

2. Supplies (inventory)
   - what to get
   - how to get it
   - how to prevent theft, waste and breakage
   - organize tools and materials

3. Arrangement of lab (furniture and layout)
   - design furniture
   - design layout of lab

The Safety Group begins by writing to various safety-oriented organizations requesting information, posters, and pamphlets about accident and fire prevention and local fire regulations. These letters also contain an invitation for each organization to send a representative to visit the class. Organizations include the state and national safety councils, the local fire department, and the Red Cross. To find the safest tools, the children also write to tool companies and telephone local department and hardware stores to obtain catalogs.

To gather information, members of the Safety Group in a fourth-grade class in Watertown, Massachusetts, wrote letters to (1) the state office of the Occupational Safety and Health Administration, (2) the Massachusetts Safety Council, and (3) the National Fire Protection Association. The children received posters and pamphlets relevant to their investigation, and as a result of one letter, a captain from the local fire department visited the class and spoke about fire prevention in homes and schools. (See log by Marie Salah.)

While waiting for responses, children in the group discuss and draft a set of safety rules for the lab.

Children in the Watertown class kept a tally of unsafe behavior in the lab (e.g., not wearing safety goggles) and enforced their rule which stated that a student who accumulated ten violation marks could not use the lab for a week. Earlier, the entire class had established rules prohibiting misbehavior in the lab and had decided upon actions to be taken against student offenders: for example, "Throwing equipment in the Design Lab; the student responsible is forbidden to use the Design Lab for one week if caught three times." (See log by Marie Salah.)

The Inventory Group discuss which tasks they should tackle first. Most are anxious to determine which tools and materials to buy, until one child suggests trying a scrounging campaign before doing anything else. "That way we might get some stuff for free that we were going to pay for," she explains.

All agree, and in a short while they lay out the following steps for soliciting donations of tools, supplies, and scrap materials:

1. Write letters to parents and to some local businesses.
2. Make an announcement on the school intercom.
3. Place a notice in the school newspaper.
4. Put up posters in the halls.

They decide to receive donated items in their classroom but to store the materials in the Design Lab room, which has plenty of space and a lock on the door.

Lacking a Design Lab in their school, children in the Cotuit class brought from home the assorted tools they needed to build weather instruments. They solved their wood shortage by requesting scrap pieces from construction workers who were building an addition to the school. The children returned to their classroom with three boxes of wood which they cut into smaller pieces and sanded. (See log by Phyllis Viall Cooper.)

With their campaign underway, the children turn to other tasks. To decide upon priorities, they first prepare the following list:

1. Find out from students in school what tools they think the lab should have.
2. Write to other schools with Design Labs to find out about their inventories.
3. Find out which sizes of tools children use most comfortably.
4. Decide on a way to raise money for buying supplies.
5. Decide where to buy items.
6. Keep track of inventory.
7. Make up a system for keeping tools and materials organized.
8. Remind students to take care of supplies and not to steal any.

"Getting answers from other schools will take a lot of time because we'll have to wait for the mail," says one student, "and I think we should do that first." But another child points out that they should first make an inventory list "so we can tell other schools what we have and they can tell us what we need."

Agreeing with this suggestion, one group member remarks, "It would be good to have a list so that we can add to it when people donate things."

This debate continues until one previously silent member says, "We can do both at the same time; all we have to do is split up into two little groups for a while." The group concurs, and the children decide that afterwards they will check with students about preferred types and sizes of tools, leaving the money, shopping, and organizing problems for later.

Some children in the group compile the inventory list and others enclose copies with the letters that they send to teachers in nearby school systems. (Their teacher has furnished a list of appropriate teachers and schools.)

A fifth-grade class in Howell, Michigan, decided they needed advice about selecting the inventory for their school's new Design Lab which they were setting up. Consequently, they got in touch with the art teacher, the high school shop teacher, the Design Lab manager at a nearby school, and the USMES Project Design Lab Coordinator. As each suggestion list arrived, the students checked off the items on the inventory list in the USMES Design Lab Manual. After eliminating materials received from a scrounging campaign, the class used the most frequently suggested items as the basis of their first purchase order. (See log by Janet Sitter.)

Most schools reply promptly, but in looking through the various inventories, the children wonder which list applies most to their situation. One student suggests taking an average of all the schools for each tool to determine how many hammers, how many saws, etc., their lab should contain, but the boy soon realizes that his school may not be so average.

"Why do some schools need more tools than others?" the teacher asks.

"Because they have more students," the children first say, but upon thinking further, they agree that the number of lab users is probably a more important factor. Because don't have that information, they decide to write to the various teachers.

In several days the second responses are received. The students, aided by their teacher, display the information on three scatter graphs: number of lab users in a school vs. (1) number of hammers in that school's Design Lab, (2) number of saws, and (3) number of screwdrivers (see Figure B5-1 for one example). Because the points on each of the

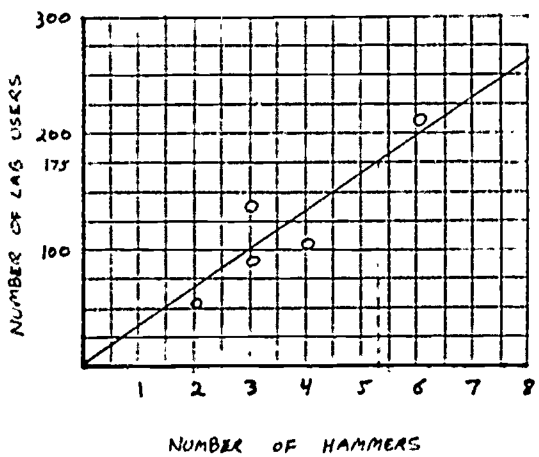


Figure B5-1

three graphs appear to lie close to a straight line, the students draw in the line on each graph. Having already found that there are 175 lab users in their school, the students interpolate on each graph to determine how many hammers, saws, and screwdrivers they should stock in the Design Lab.

Advice from the class helps members of the Inventory Group organize the next phase of their work. Based on previous observations of other classes, students give the group an idea of which tools are in demand, but they recommend that the group also make a school-wide survey of Design Lab users.

While the class discusses how the group can find out about preferred tool sizes, one student says, "Why don't you let students use big tools and little tools and see which ones they like?" Children in the group think this is a good idea--they don't want to survey every student in the school.

The teacher, realizing that the students have had little or no experience in choosing a random sample, asks questions to stimulate their ideas. She asks, "Can you figure out a way to find out how many students like each tool size without testing every student?"

One student's reply, "We can test just a few," prompts another question from the teacher. "How will you decide which group of students to test?"

"Ask for volunteers," suggests one boy.

"Suppose the volunteers are mostly sixth graders," remarks the teacher. "Will that be a fair sample?"

"We could pick out who we want to test," responds one student, "and make sure the numbers are right."

"Yeah," agrees a classmate. "We could choose two kids from each grade."

"That won't be fair either," counters one of the girls, "because there are only two first-grade classes but there are four fourth-grade classes."

A boy suggests, "How about picking one kid from every class?"

"That's no good," says the girl. "You might end up with a big 'little' kid."

"Well, we could look around and pick an average-looking kid."

Another student chimes in, "What about picking five kids from every class?"

After debating the merits of these last two suggestions, the Inventory Group decides to "play it safe" by randomly selecting five students from each class roster. In this way, the children agree, they also avoid the problem of how to determine who "looks average."

How Many Students Preferred Each Size Hammer

SMALL	MEDIUM	LARGE
20	51	24

Figure B5-2

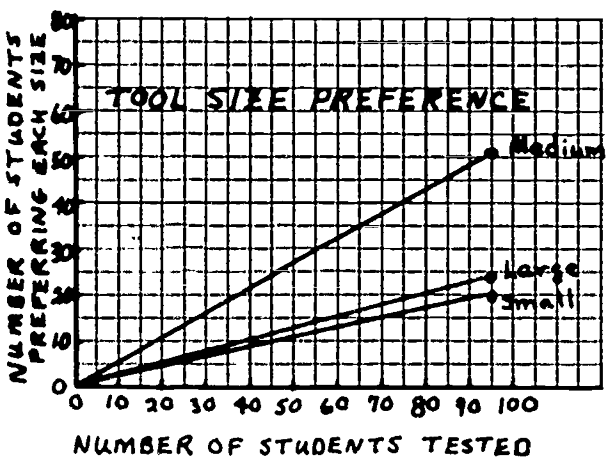


Figure B5-3

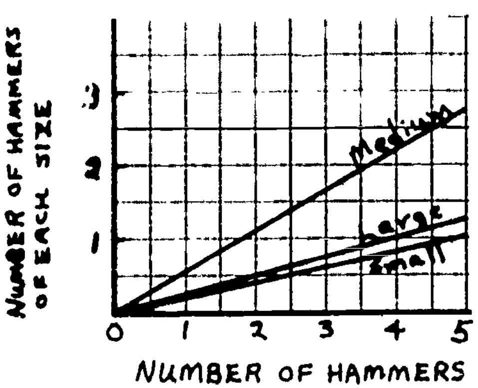


Figure B5-4

Preliminary details for this activity include getting hammers and saws of various sizes and writing notes to teachers requesting permission to take students out of classes or during lunch. The children handle these chores, and before the first testing session, they decide that if a selected student is absent when needed, they will choose the next name on the class listing.

Tools in the Design Lab were too large for most of the children in a second-grade class in Arlington, Massachusetts. As part of their work on a Design Lab Design challenge, these students tried out smaller tools at a local hardware store and purchased a hammer, a screwdriver, and some short and thin nails. (See log by Sally Callahan-Chebator.)

Testing proceeds at a hectic pace, and within a week the group has collected data on ninety-five students, five from each class, including their own. As expected, the results point out that younger children tend to prefer smaller tools. In evaluating their data, the group members realize that some students may have just said they preferred bigger tools without really meaning it. They decide, however, to accept the data, seeing no other practical alternative. (See Figure B5-2.)

Analyzing the data requires help from the teacher. The students first draw a bar graph showing the numbers of children who prefer each size hammer. However, they realize that this graph will not help them determine how many of each size to buy for the lab. The teacher draws a slope diagram on the board (see Figure B5-3) and explains how the children can visualize the ratio of the number of students who prefer a certain size hammer to the total number of students tested.

After the children see that the slopes of the lines on the diagram indicate these ratios, the teacher asks, "How many hammers all together are you planning to have in the lab?"

"Five," the children reply, and the teacher then shows them how to draw the slope diagram illustrated in Figure B5-4. The teacher points out that both of the number lines on the first diagram are the same; therefore, both on the second diagram must be the same. On the second diagram, the children draw lines with slopes approximately equal to those of the lines in the first diagram. The points at which these lines (in Figure B5-4) intersect the vertical number line indicate the proper numbers of tools of each size.

"We can't buy 1 1/3 large hammers!" exclaims one child.

"Or 2 2/3 medium hammers!" says another.

"What can you do?" asks the teacher. The children decide to round off these fractions to one and three, respectively. Therefore, the lab will contain one small hammer, one large one, and three medium-sized ones. By repeating this procedure, the children also determine how many saws of each size they need.

Meanwhile, the children in the Furniture and Layout Group have begun their task by trying to determine which types of work areas they should incorporate into the lab. Based on their experiences with the portable lab and their observations of other classes, the children list the following lab activities:

1. sawing
2. gluing
3. soldering
4. hammering
5. painting
6. designing
7. reading
8. calculating
9. sanding
10. drilling

Sawing requires a separate workbench, they agree, because people like to saw at a low table. They also decide to plan for a power-tool station and a gluing/soldering area. "These should be close together so the electric wires will be in one part of the room and won't get in everyone's way," remarks one child. Agreeing with this idea, the children also include in their plans stations for painting, general construction, and quiet work, and they agree to allocate areas for storage of tools and materials.

Challenged to design a portable lab using two mobile carts, children in a combination fifth/sixth-grade class in Lansing, Michigan, discussed how to distribute the tools between the two carriers. They chose to put the electric drill and saber saw on one cart and assigned the glue gun and soldering iron to the other. In this way, the noisy power tools would remain together and could be wheeled to a portion of a room where they would be least obtrusive. (From log by Gregory Weatherspoon.)

"How big should we make the tables?" asks one group member, sparking a lengthy discussion. The children try to recall from their observations of other classes the highest numbers of students working on each type of activity at any one time.

"Only eight people wanted to saw at the same time," one child notes. Another mentions that the power-tool station has to accommodate only two workers because the school has just one saber saw and one electric drill.

"But we may get more," another child counters, and the group concurs that the table should be big enough for four people. (They later check this with children in the Inventory Group who say they probably will propose adding more power tools to the current stock.) After deciding upon a capacity for each table, the children wonder about appropriate dimensions.

Different activities require different amounts of working room, the children agree, and they decide to collect additional data. They visit a class that is using the portable lab, and as students hammer, saw, use power tools, etc., members of the group make chalk marks on the floor to designate the required working space. To record their data, the children measure and write down the diameters of the circular areas and the dimensions of the rectangular areas they have marked off.

To use their limited classroom space efficiently, children in the Cotuit class planned a 3 ft. by 6 ft. workbench. On the floor, they chalked an outline of the proposed table top and asked different numbers of children to stand around the figure and pretend to hammer and saw. The group determined that eight children could work comfortably at that size table although the capacity would vary with different activities. (See log by Phyllis Viall Cooper.)

Back in their own classroom, the children try to derive from their data the dimensions and the number of workbenches needed for each activity. However, problems of limited floor space force them to cut back on the working capacity of several work stations. For example, they want to make the hammering station big enough to accommodate ten people, but they have found that each worker needs a three-foot-square areas in addition to the areas needed for other activities. They postpone making final decisions about the size of each work station until they have measured the lab room.

Challenged to move their Design Lab to another room, children in the Sterling Heights class measured the dimensions of the lab furniture and of the new room. Using a trial and error technique with sketches drawn to scale on graph paper, the children designed a layout that was safe, roomy, and efficient. (From log by Marjorie Girardot.)

Interaction among the three groups becomes prominent at this stage in the children's work. For example, before selecting a final lab arrangement, the Furniture and Layout Group must learn about fire regulations from the Safety Group and about the need for storage facilities from the Inventory Group. In turn, the Inventory Group must get advice from the Safety Group concerning first-aid materials and protective items such as goggles, aprons, and gloves. Also, because the Inventory Group's responsibilities include obtaining supplies for the lab, the children in this group must find out from the Furniture and Layout Group the amount and types of supplies needed to construct lab furniture.

Undaunted by this seemingly intricate network of dependency, the three groups periodically make presentations during class discussions scheduled by the teacher. As part of these reports, the groups list which information and/or recommendations they need from one another.

Unexpected interactions also occur. The scrounging campaign conducted by the Inventory Group results in the donations of three old but sturdy wooden doors. Informed immediately, the children in the Layout Group alter their workbench designs to make use of the newly acquired items. They decide to make three worktables, using screws to attach each door to two sawhorses.

Sixth-grade students in Ganado, Arizona, who were converting a large custodian's room into a separate Design Lab area, took advantage of two available workbenches. Because both were suitable heights for older students but too high for most fourth graders *and younger students, one group built a riser to accommodate shorter children. Another group worked on upgrading the inadequate lighting. Using wood and wire, they made a ceiling attachment onto which they placed clamp-on lights. Two such constructions greatly improved the lab lighting. (From log by Alice Hunt.)*

Recommendations from the Safety Group prove especially valuable to the other committees. For example, the Layout Group learns of a public-building regulation that says, "All furniture in the classrooms must be kept at least THREE (3) FEET AWAY from all exit doors." Realizing that their present design violates this rule, the children move several tables on their layout to allow proper clearance. In rearranging, they eliminate one table because there is no longer adequate room around it for people to work. Similarly, the Inventory Group modifies its plans as a result of three recommendations from the Safety Group:

1. Power tools should have spring-loaded on-off switches.
2. The lab should have goggles, aprons, work gloves, and a first-aid kit.
3. Paints should be water-based; the lab should not contain oil-base paints or turpentine.

Aside from funnelling useful points to other committees, the Safety Group makes plans to disseminate information to all lab users. From among the posters and pamphlets they have received, they select the "best" ones for hanging in the lab and in the halls. In addition, they decide to make some of their own "dos and don'ts" posters. The group also devises a training program whereby students in the class will show primary-grade children how to use tools safely and effectively.

During a class discussion the Howell students listed potentially unsafe conditions that might arise in the Design Lab; for example, using tools incorrectly, not wearing safety goggles when needed, not following directions. The class decided to make posters for the lab, stating safety rules in a positive manner--"Use tools correctly." "Wear safety equipment *when using power tools." "Follow directions." Just before the lab was opened for school use, the class formulated procedures for using the lab which included rules for signing up in advance, adult supervision, and a maximum number of students to be allowed in the lab at one time. (See log by Janet Sitter.)*

Members of the Furniture and Layout Group similarly put the finishing touches on their tasks. Once they have chosen a layout agreeable to all in the class, they decide to measure students to determine suitable heights for the workbenches. Akin to the Inventory Group's survey involving tool sizes, this group selects five students from each class and the children measure the waist-to-floor distance for each student. From a histogram of their data, the children decide to plan for two sawing tables (one 75 cm high and the other 90 cm) and two workbenches to use for general construction (one 90 cm and one 105 cm high).

To determine a suitable height for the workbench they were building for their in-class Design Lab, five children in the Cotuit class measured on each other the distance from the floor to a point between hip and waist. They calculated the mean of these measurements, rounding off to thirty-six inches. Although the yard-high workbench proved convenient for most activities, it was too high for sawing comfortably. Therefore, the children modified their second workbench, making it six inches lower. (See log by Phyllis Viall Cooper.)

Before going to the lab, the children in the Furniture Group turn to the question of table shapes. Squares, rectangles, circles, and triangles number among the suggestions, and initially each receives an equal amount of support. However, one child points out that wood usually comes in "squarish" shapes; therefore, making a circular tabletop would produce a lot of wasted corners.

"But we can always use scraps of wood," says one circle defender.

"But sawing circles takes a lot of time," retorts another child, thus sealing the fate of round tables.

Further discussion narrows the choices to squares and rectangles. One student thinks a rectangular table can "fit more people around it." When another child says that a square can accommodate an equal number of people, the first replies, "Yeah, but you have to make it a lot bigger."

The deadlocked group seeks advice from the teacher, who helps the children compare the economics of the two shapes. The children draw on graph paper a square and a rectangle of equal working capacity (i.e., equal perimeter). They count the number of boxes (area) inside each sketch to determine how much wood each type of table would require. The children discover that a 4 cm by 4 cm square and a 2 cm by 6 cm rectangle each have the same perimeter, but the rectangle has a smaller area.

After trying this comparison using different sets of dimensions, the students agree that a rectangular workbench requires less wood to build than a square workbench if they "are the same distance around." One child continues drawing and counting on graph paper and then blurts out, "We can save even more wood if we make worktables that are really long and skinny."

"But if the table is too skinny, our projects will fall off," another student points out.

Now that they have settled the shape issue, the children measure the length and width of the lab room and make a scale drawing on which they plan to try different layouts and table dimensions. They reduce to scale their proposed dimensions for workbenches, and using cardboard, they cut out scale patterns to place on the drawing of the room. On each pattern the children mark the job to be done and the number of people who can work on that job in that space. Through trial and error the children arrive at the dimensions and arrangement of tables that they feel make the best use of the lab's floor space.

One group of fourth graders in the Watertown class initially planned to use yardsticks and rulers to measure the Design Lab room as a first step in making a scale drawing. However, they took advantage of the tiled floor and measured the lab and the furniture by counting tiles. Then they drew a grid on a piece of Tri-Wall, letting one square represent one tile. Next, they placed a piece of transparent plastic over the grid and used grease pencils to draw in the furniture. (See log by Marie Salah.)

The Inventory Group also completes its work. Having received replies to the letters they sent to other schools, the children sort through the information. After they make appropriate additions to their list of needed supplies, they check this list against a list of scrounged and donated items, crossing off those tools or materials they no longer need to purchase or altering the required quantities.

Pricing becomes the next concern of this group, and the children eagerly make arrangements for a comparative shopping trip. Because the town and its vicinity contain several each of hardware, stationery, discount, and department stores, as well as two lumberyards, the children form subgroups and obtain parent chaperones to expedite the job of visiting so many stores.

"Let's make sure we write down the price and the size and everything else that might be important, like how good it is," one student urges just before the group leaves. "Agreeing that the suggestion is a good one, the children devise a simple data collection sheet with columns designated for the different types of information they will obtain about each tool.

When their principal approved their request to buy tools for the Design Lab, children in a third-grade class in Plainfield, New Jersey, had to determine where to buy the equipment. After each child asked his or her parents for suggestions, the class discussed the recommendations and decided to deal only with a store that offered a money-back or replacement guarantee. By telephoning stores, the children narrowed their choices to two and then voted to select one of these. (From log by Barbara Briggs.)

Houston students began a telephone survey of local stores to find out about available tools and their sizes and prices. During a class discussion one girl remarked, "I found out that lots of people won't talk to kids. They just put you off or hang up." When several other students echoed agreement, the teacher asked what could be done to resolve this difficulty. After various solutions were offered, the students agreed that they needed a short introduction for their requests. They decided to tell the store clerks who they were, including their *school and teacher's name, and why they were calling. If the salesperson sounded receptive, their final question would be whether the store offered a discount for a school project. (From log by Robert Lindley.)*

After their shopping trip, the children devote two lengthy sessions to compiling and discussing their cost data, which includes information from the tool and materials catalogs that the Safety Group has acquired. For most items, the children have no trouble with cost comparisons, and they concern themselves with discussing price/quality tradeoffs.

A debate arose in the Howell class when the students had to decide whether to buy cheaper brands of tools with guarantees. At first one student's argument prevailed: if the cheaper brand of saw were purchased, it could be replaced twice before the cost would equal that of the guaranteed saw. The class agreed on the less expensive brands until they reread the advice of the USMES Design Lab Coordinator against purchasing cheap tools. On reconsidering the difficulties they might encounter with cheap brands, the students decided to stick with the guaranteed tools unless a cheaper brand provided a substantial saving. (See log by Janet Sitter.)

When the students review the data on lumber, they are somewhat confused by the variability in sizes until their reacher reminds them about slope diagrams. Trying this technique with different lengths of two-by-fours available at each of the two lumberyards, the children see that a twelve-foot piece from one of the yards provides the lowest price per foot. They place this item on their pricing chart, which contains these headings: item, store, quantity, price per unit, and total price for item. After completing their chart, the children add the total-price column to arrive at the total amount of money they need for buying lab supplies.

All the groups organize for an important class discussion on merging the various proposals and information into one comprehensive program for setting up the Design Lab. The children decide that the Safety and Inventory Groups, both of whom are planning a poster campaign, can work together on this activity to avoid repetition and to ensure completeness. These groups will also combine what they want to tell people into one notice for the school newspaper and one intercom announcement.

During the session, money emerges as the prime consideration, and the class suggests the following ways to obtain funds:

1. Ask the PTA.
2. Have a sale, e.g., a bake sale or garage sale.
3. Ask the principal or the school board.
4. Make more geoboards and sell them.

Students in Boulder, Colorado, increased their Design Lab inventory by scrounging items and by earning money through an "everything sale." "Everything" included plants, pets, baked goods, fish bait, crafts, and anything else they could get. After obtaining the principal's approval, the class launched their advertising campaign, scheduled times for student workers, and held a successful, six-hour Saturday sale which netted eighty dollars. (See log by Margaret Hartzler.)

Time is a factor, the class agrees, and on that basis the children decide to make a presentation to the PTA, 'escribing what they have done and what they plan to do and requesting the necessary funds. If that fails, they will try one of the other suggestions.

After discussing what makes a good presentation, the children outline what they will say to the PTA and how they will say it. The class agrees to open with an introduction, followed by a report from each group. One child says the Inventory Group should go first, "because they're the ones who are going to ask for the money."

Another student suggests the opposite, "They should go last so the other groups have a chance to build up everybody's excitement." For the best effect on the audience, the class finally approves of this order: introduction, Safety Group, Furniture and Layout Group, and Inventory Group.

Preparing charts, drawings, and sample posters and writing and rehearsing speeches keep the children busy for the next few sessions. They arrange for time at the next PTA meeting and obtain parental permission to attend the evening affair. Aware of the importance of the upcoming event, the children constantly check on and help one another.

Their presentation runs according to plan. Two children share the introduction responsibilities, briefing the listeners on how the class became involved in setting up the Design Lab, how they planned their strategy, and how they split into three groups. Members of the Safety Group explain how they gathered information, show a sample poster as they talk about their plans to ensure safety in the lab, and outline their proposal for a training program for younger children. Children from the Layout Group present a large scale drawing of the proposed layout, explain the basis for their decisions, and exhibit a diagram of their plans for the sawhorse/door workbenches. The Inventory Group first presents a chart listing the materials they have scrounged. Then, after describing how they selected and priced the items they wish to purchase, the children make the request for funding.

Approval comes quickly, and the children become exhilirated but soon settle down to implementing their program. Materials needed for constructing the workbenches take priority, the children decide, and they arrange to purchase two-by-fours and sawhorse brackets the next day.

As the lab takes shape, the children find additional tasks to perform. Organizing the tools and materials, preparing a sign-in/sign-out sheet, and deciding who will keep track of supplies all fall to the members of the Inventory Group. The Safety Group appoints some members to draw up an accident-report form to provide a means for monitoring lab safety. The Layout Group observes other classes working in the lab to check on traffic flow in the various parts of the room, and a newly formed Evaluation Group devises a survey to determine how lab users feel about various aspects of the new lab and whether they have any suggestions for improvement.

For the remainder of the year, the follow-up activities keep the class happily occupied. In a class discussion just before summer vacation, the children proudly agree that they have met their challenge and have provided a useful service for their school.

6. QUESTIONS TO STIMULATE FURTHER INVESTIGATION AND ANALYSIS

- What are some of the things you like about working in the Design Lab? What don't you like? How could you make the lab a better place to work?
- What kind of changes would you like to make to improve the lab? Are there enough tools and materials? Can you easily find what you need and use it when you want? Are there ways to make the lab safer?
- Who else might know about problems in the Design Lab? How can you find out their opinions?
- Which of the changes should you work on first? Which problems are most important?
- What data do you need for your investigations? How/where can you get it?
- How do you know your data is accurate? What does the data tell you? How can you make your data clear for other people?
- What kinds of tools should the Design Lab have? Is the supply of tools and materials sufficient for the number of lab users?
- How can you find out what sizes of tools children prefer? What do you do if different people like different sizes?
- Where can you get advice about selecting tools and supplies?
- How can you obtain supplies without spending money?
- How can you raise money to purchase items for the lab? How will you determine where to buy supplies?...how much they will cost?...which size, brand, or store offers the "best buy"?
- How can you keep a record of Design Lab items? How will you know when certain supplies are running short?
- How can you eliminate having to wait to use the lab or certain tools?
- How can you find out how big, how high, and what shape to make a workbench?

- How can you try out different lab layouts without moving the furniture?
- How can you find out about fire regulations?...accident prevention?...how to use tools safely?
- How can you remind people to clean up?...to put tools in the proper places?...not to waste materials?...not to tamper with other students' projects?
- How can you find out whether noise from the Design Lab is a problem? How can you measure noise? What instruments do you need? Where can you get them?
- How can you find out whether your changes have been effective?
- What will you do to keep your programs running next year?

C. Documentation

1. LOG ON DESIGN LAB DESIGN

by Sally Callahan-Chebator*
Thompson School, Grade 2
Arlington, Massachusetts
(February - March 1975)

ABSTRACT

This second-grade class worked on their Design Lab Design challenge for about an hour each week for two months. The children first listed problems they had encountered while working in the Design Lab and after an observation period, expanded their list. They decided to form two groups to focus on two problem areas: (1) safety in the lab and (2) obtaining smaller tools for younger children. The Safety Group made four posters listing safety rules and hung them in the lab. The Tool Group obtained permission to visit a local hardware store where the children tried out tools of various sizes and purchased several smaller ones for the Design Lab.

After they had completed Designing for Human Proportions, I asked my second-grade students what they thought about using the Design Lab. Although they all made positive comments, I asked what problems they had encountered in the lab and challenged them to think of ways to improve the lab.

One student volunteered to take notes and recorded the following comments from the children.

"You can get cut by a power saw."
"No glue for the glue gun."
"You can get hurt by the nails"
"All the wood and Tri-Wall can get on fire."
"If the fire gets in the room, you can never know."
"We need more nails."
"The hammers are dangerous."
"We need signs about what to do during a fire drill."
"We need more signs."

We then visited the Design Lab to see whether we would notice any other problems, and afterwards we added the following comments to our list.

*Edited by USMES staff

"Nails are left around."
"Things aren't put away."
"There's wood all over the place."
"If you leave tools plugged in, somebody can get hurt badly."
"Don't touch the hot pipes."
"The wood is too hard to nail into." (We tried this and it was true.)
"Paper all over the place."
"There are seventy-six nails on the floor."

At the next lesson I asked for a new recorder, and we spent about fifteen minutes deciding how we should choose a recorder for each session. The children favored pulling names out of a hat.

After we read our notes from the previous session, I mentioned the possibility of obtaining ideas for improving the Design Lab from other lab users in the school.* The children suggested the following ways to obtain outside opinions:

1. I should ask the other teachers at lunch to question their classes about the lab.

2. The children should go to other classes to ask the teachers or students directly.

3. The class should ask other children during lunch (though my class had lunch with only one other grade).

None of these suggestions seemed really practicable to the children. I explained surveying to them, using a sample questionnaire that I wrote on the board, but the concept never caught on with them. The children decided not to seek other students' opinions but only to work on their own ideas for improving the Design Lab.

Parents who staffed the lab created a new problem for us. These volunteers, who didn't understand that the children should improve the lab themselves, made some changes without the children's help. However, other improvements did remain for the students to make.

Ideas from the class focused on two objectives: (1) making posters to remind children about safety in the lab and

*The teacher might ask whether the children thought that other classes had the same problems in the lab, and how they might find out.--ED.

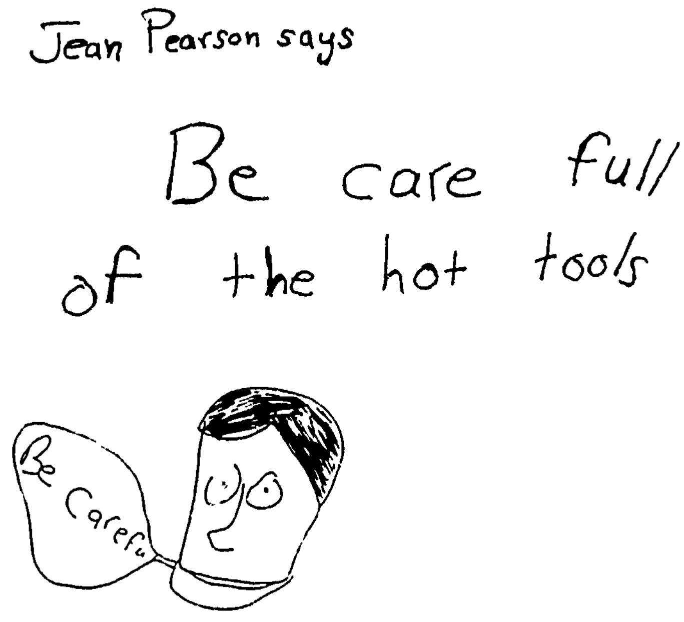
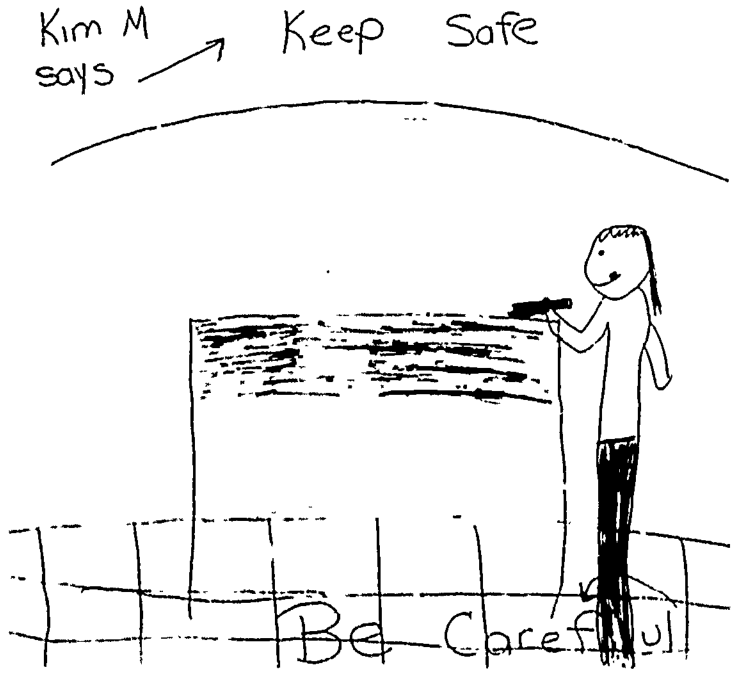


Figure C1-1



99 *Figure C1-2*

(2) obtaining tools small enough for the younger children to use easily. The class split accordingly into two groups, while children who showed no interest in either problem did their own work.

The Poster Group planned four signs and then drew them on oaktag with markers. When the children completed this task, the class discussed their signs and recommended that the group redo some of the lettering to make the writing clearly visible from a distance. The students heeded the advice and then hung up the posters temporarily in the classroom until our next trip to the Design Lab. (Figures C1-1 and C1-2 show copies of two of those posters.)

The Tool Group first discussed how to find out about small-sized tools and made these suggestions:

1. Write letters to companies requesting information.
2. Go to a tool store.
3. Walk to the tool store in Arlington Center.
4. Take inventory.

Children in the group favored the third suggestion, and we discussed how we would prepare for our trip to the hardware store:

1. Let the store know we were coming.
2. Get permission slips from our parents.
3. Get approval for the field trip from the office.
4. Get a wagon to pull Kim (a girl on crutches).

Before the next session, I telephoned the store. I then told the class that the owner had said we could come if we made an appointment but the only tools he stocked in different sizes were hammers and saws. Not minding this lack of variety, the children recommended that we take our own hammer and saw, as well as wood and nails, for a better comparison of the different sizes of tools.

Together we filled out the field-trip approval form for the office and worded the parental permission slips. The students decided to write their own slips rather than wait for the office to type and duplicate them.

Out of enthusiasm for our upcoming journey, the children asked me to telephone the store immediately to set up an appointment. They promised to remain quiet while I phoned, and they kept their word as I arranged an appointment for the following week.

Unseasonably cold weather prevented us from walking to the store, but the principal called each parent to receive verbal permission for us to use public transportation. At the store, each child tried tools of various sizes, compared these with the hammer and saw from our lab, and expressed their choices for purchases. Although the larger children liked the bigger tools, they kept in mind the purpose of our trip--to obtain smaller tools.

Our lab saw was larger than any of the saws usually stocked by the owner. (It was either longer, heavier, larger-handled, or a combination of these.) The children decided to buy the shortest saw because to them length seemed to be the most critical factor for ease of handling. Because the owner had run out of the short saws, we ordered one.

While testing hammers, one student tried a "child's" hammer and agreed with the store owner, who said that such tools lacked the sturdiness and durability needed for our purposes. However, both sizes of "adult" hammers were smaller than the one the children had brought. The students purchased a hammer, a screwdriver and some nails, which were shorter and thinner than those from the lab.

Back at school, we brought the new supplies to the lab and updated the inventory list, at which point the children felt they had done their job.*

*The class might review their list of problems in the lab and decide whether they wanted to work on any of the other problems. They might also observe other classes working in the lab and see how often the smaller tools were used.--ED.

2. LOG ON DESIGN LAB DESIGN

by Marie Salah*
Hosmer School, Grade 4
Watertown, Massachusetts
(February - May 1974)

ABSTRACT

For four months this class of fourth graders spent from three to six hours per week on Design Lab Design while they also completed work on the School Zoo unit. Recurring problems in the lab during the construction of animal cages had led to the introduction of the Design Lab Design challenge. Students listed problems concerning safety, inventory, and misbehavior; offered possible solutions; established a set of rules for the lab; and formed three groups to resolve the problems. Some children in the Organization Committee made a scale drawing of the lab to help them rearrange the layout, some constructed a large locking cage to protect six small animal cages, and others labeled cabinets according to contents, made a box for scraps, and organized loose materials into containers. Children in the Safety Group kept a tally of unsafe behavior, enforced safety rules, and gathered information and materials by writing to safety-oriented agencies. A fireman visited the class as a result of one student's letter. The Tool Committee heavily modified a mobile cart so that tools remained better organized during lab sessions yet could be stored in a locked compartment built into the carrier. This group also kept track of inventory, instituted a system for signing out tools, installed a burglar alarm, and made large "how-to" posters.

Our work on Design Lab Design evolved from the School Zoo unit for which the children designed and constructed animal cages in the lab. Because several problems kept recurring, I introduced the following challenge: What types of problems do we have in the Design Lab, and how can we eliminate them? The children listed the following problems and possible solutions:

Problems	Possible Solutions
1. lack of tools	1. scheduling tools--ten to fifteen minutes per person

*Edited by USMES staff

Problems	Possible Solutions
2. safety hazards-- burns, cuts	2. safety procedures: a. more supervision b. goggles for eyes c. gloves for glue gun and cutting d. unplugging equipment while not in use e. safety posters
3. theft of equipment	3. burglar alarms and locks for tools
4. students not using tools properly	4. displaying "How To" Cards on use of tools
5. fighting and loitering	5. rules for discipline problems
6. students throwing equipment	6. safety rules to follow

Through class discussion the children established the following rules:

1. One tool at a time may be checked out by an individual.
2. Loitering and fighting: the person will be excused from the Design Lab.
3. Damage to other students' property: the student responsible is eliminated from the Design Lab for one week.
4. Throwing equipment in the Design Lab: the student responsible is forbidden to use the Design Lab for one week if caught three times.

To study the problems further and produce corrective action, the students organized the following committees:

1. Safety Committee
2. Tool Committee
3. Organization Committee

After reviewing our lists of Design Lab problems and tentative solutions, we discussed how each committee would help make the lab a better place in which to work. From

Science 3/4/74

We are making posters telling the class how to keep the lab neat and clean.
We are trying to find out what is in the Science Lab, and how many there are.
We made a scrap box for scrap board, paper, wood, etc.
We are also planning to ask parents friends, and relatives if they had any scrap boards paper, wood etc.

The Organization Group

Figure C2-1

this discussion each group decided upon a set of objectives and also agreed to elect a secretary to keep notes of daily progress. For the remainder of the school year the children worked in their three groups.

Organization Committee

When we entered the Design Lab after our class discussions, members of this group showed the most enthusiasm. They split into subgroups to begin progress on their objectives and intended actions which they had listed as follows:

1. Scrounge for materials (e.g., screen, plastic, cloth, etc.).
2. Keep the room clean and organized.
3. Label cabinets.
4. Schedule classes.
5. Find storage room for scraps.
6. Make additional rules for the Design Lab.
7. Find suitable containers for nails and other equipment.
8. Advertise for other classes to use the room.
9. Rearrange the furniture to provide the most efficient work space.

Two students cleaned the bookshelves in the lab and obtained plastic containers and bags for loose materials (beans, soap, macaroni) that were often dropped on the floor or misused by students. Another pair of students labeled cabinets so that materials could be found more easily. Still another pair picked up large scraps of paper, wood, cardboard, etc., and put them in a large storage box that the group had made. One student prepared posters that displayed rules for persons using the lab to follow. The committee also initiated a scrounging campaign by making plans to request scrap materials from parents, friends, and relatives. Figure C2-1 shows the Organization Committee's progress report of initial acrivities.

Rearranging the furniture in the lab to provide more working space also counted in this group's plans. During a committee meeting I asked the children whether they could think of a way to try different layouts without actually moving the furniture. We discussed scale models and decided to ask one girl's father, an architect, for advice.

Mr. K. arrived the next day, forewarned by me not only about the working-space issue, but also about a new problem picked up by the Organization Group: how to prevent students from releasing animals from cages. Our visitor

9 Tilleys ½ a students Desk
6 and ½ Tiles make a Teakners Desk

37 ½ W
39 ¼ L
3.2 Desk
3 ½ closet
4 ½ B scinece Room 39 ¼

35 ½ by 4 cabints

Scale Plan of Classroom

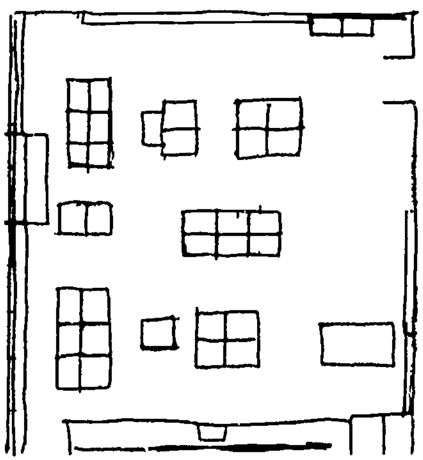


Figure C2-2

divided the committee accordingly into two subgroups and worked with each.

Students working on the cage problem suggested putting locks on the six individual cages. After Mr. K. pointed out the expense of such a procedure, one child noted that using chain locks would cut costs because one chain lock could protect two cages at once. Another child made an even more economical recommendation--buy just one lock and build a cage large enough to contain all the other cages. The group accepted this idea and began drawing construction plans.

The other subgroup initially planned to use yardsticks or rulers to measure the room as a first step in making a sca'ᵓ drawing. However, these students took advantage of the ciled floor and measured the lab and the furniture by counting tiles. They drew a grid on a piece of Tri-Wall, letting one square represent one tile. Then they placed a sheet of transparent palstic over the grid and used grease pencils to draw in the furniture. (Figure C2-2 shows a copy of the measurements and the scale drawing produced by one pair of students.) Both subgroups continued their work in later sessions.

The girls working on rearranging furniture concentrated their efforts on two movable worktables (most other furniture was immobile). On the scale plan, the children tried a couple of side-by-side positions, first in one direction

and then in the other

but neither provided much work space. Combining these ideas allowed increased space,

but the girls had the tables on the side of the room that contained few electrical outlets. Again, they modified their arrangement

and placed this configuration in the part of the room with sufficient outlets. Satisfied with their plan, the girls had other students help them move the actual furniture. The new, more spacious arrangement pleased the class.

Initial plans for the large cage incorporated four walls made of screens and a Tri-Wall top and bottom, all placed on a wooden frame. (Figure C2-3 shows a copy of one student's design.) The children revised their design when one of our parent helpers brought in four window screens; this donation eliminated the need for a wooden frame.

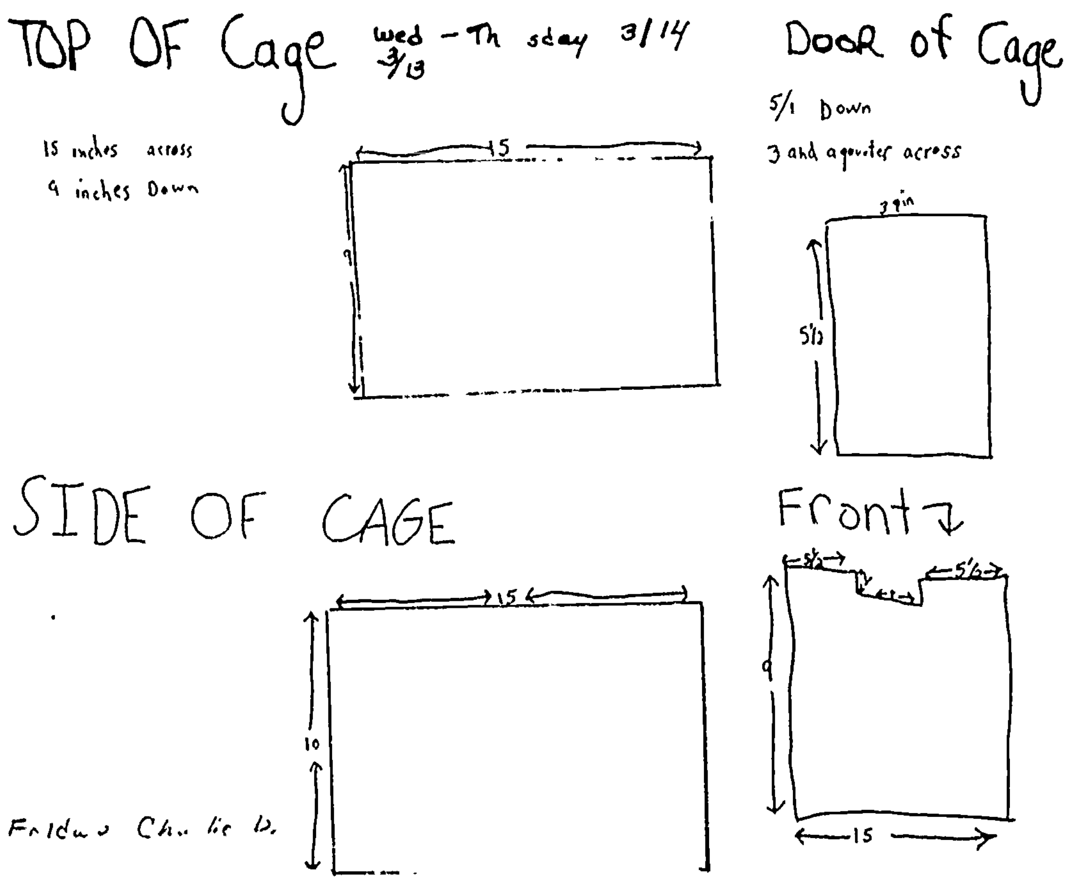


Figure C2-3

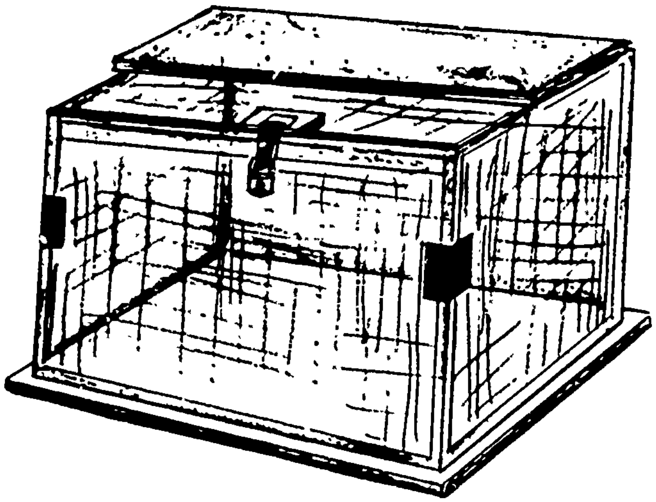


Figure C2-4

I asked the students whether they could guarantee that all six cages would fit inside their large cage and they said they weren't sure. To check, they held up the four window screens, tentatively forming the cage, and asked another student to place the smaller cages inside. All six fit, and the group was ready for construction. The boys measured and cut Tri-Wall pieces, glued together five sides of the cage, and added wooden hinges to allow the front door to slide up and down securely. They also made a latch by attaching a metal piece with a hole to the top and another metal piece to the door of the cage. (A facsimilie of their cage is shown in Figure C2-4.)

Soon after completing the large cage, the boys found it partially destroyed--wooden hinges torn off and broken and the top screen deformed. They repaired the screen with masking tape and replaced the wooden pieces with one long Tri-Wall hinge that allowed the front door to slide into place sideways rather than from above.

While these two subgroups had worked on the cage and scale drawing activities, other members of the Organization Committee had busied themselves with continuing tasks such as organizing and labeling cabinets with an assortment of other jobs such as constructing a Tri-Wall box for cassette tapes.

Safety Committee

Early in the unit, this group outlined the following objectives:

1. Start a first aid kit and keep it supplied at all times.
2. Make coverings for the tools for safe storage.
3. Draw safety posters to prevent accidents.
4. Keep statistics on accident rate in the lab.
5. Find more volunteers to supervise the Design Lab.

Hampered by an inability to focus on these aims, the Safety Committee did not accomplish as much as the other groups. For example, three members ignored the group objectives and began inappropriately by constructing burglar alarms for the cabinets, desks, and doors. Also, two boys responsible for assembling a first aid kit felt they had completed their task after they obtained from the nurse an assortment of plastic bandages and some burn ointment. Plans to make safety aprons for students and coverings for tools lost steam after some initial work. A group of children measured students' waists, cut out a basic pattern

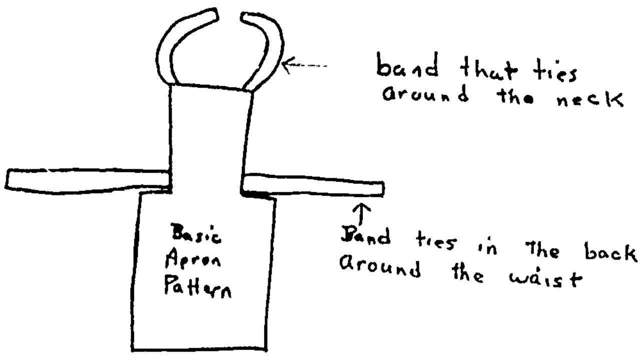


Figure C2-5

(see Figure C2-5 for a drawing of their pattern), obtained old sheets from parents, and began sewing the aprons, but the tediousness of the job and the lack of help from other group members resulted in their dropping the project.*

However, the group did register some successes. The students prepared a number of safety posters and hung them in the lab. These reminders centered on such themes as "Wear gloves while using the glue gun" and "Don't throw tools around" To gather information about safety, the children wrote letters to (1) the state office of the Occupational Safety and Health Administration, (2) the Massachusetts Safety Council, and (3) the National Fire Protection Association. (Figure C2-6 shows a rough draft of one student's letter.) In their letters, the children requested posters and pamphlets and invited a representative to speak to our class. Replies came, containing posters, which the children placed on the walls throughout the lab. As a result of one letter, a captain of the local fire department came to our class to speak about fire prevention in homes and schools (see Figure C2-7). After the visit, the children wrote thank-you letters to the fireman (see Figure C2-8).

To prevent accidents in the lab, the Safety Committee established and enforced a rule which stated that any student accumulating ten marks on the accident sheet could not use the lab for a week. On the sheet, the children kept a tally of unsafe behavior (e.g., not wearing safety goggles while using a power tool). Although a couple of boys fell victim to this ruling, most children reminded one another to use tools properly.

Mrs Salah's rm 208
Hosmer School
Winthrop St
Watertown Mass
March, 26. 1974

Gentlemen,

We would like to ask you if you could come and talk to us about Massachusetts saftey rules And if possible could you demonstrate to us how to use tools properly. We would appreciate it if you could send us some saftey posters and also saftey pampleds. We have been working in the Science lab with many hazardous tools and we would like to prevent accidents

Sincerly,
Sarah Deignan

Figure C2-6

Miss Sarah Deignan
c/o Mrs. Salah's Room
Hosmer School
Winthrop Street
Watertown, MA 02172

Dear Sarah:

A fireman from the Watertown Fire Department will be in touch with your teacher within a few days, to make arrangements for someone from the Watertown Fire Prevention Bureau to speak to your class. We are sending your letter to your fire department, so they will know what sort of program you would like.

Enclosed are a few posters and folders for your room's bulletin board. And just for you we are sending a Sparky's Fire Department membership kit. We want you to know we are pleased at your interest in fire safety -- keep up the good work!

Figure C2-7

Tool Committee

This group began with the following objectives:

1. Take an inventory of the tools.
2. Decide how tools should be shared.
3. Maintain and repair equipment.
4. Scrounge for more tools and materials.
5. Make a chart to tally tools that are used the most (would be helpful in determining whether we need more of one type of tool or not).

*The groups might present periodic reports to the class. After other groups complete their task, the Safety Committee might obtain help if the class feels that the work is important.--ED.

May 1, 1974
Hosmer School
Winthrop St.
Watertown Mass.

Dear Captain Kelly,

Thank you for Coming to our class room and telling us about fire prevention also I would like to thank you for teaching us how to have a fire drill. We are doing all that you said

Sincerly
yours
Robert A.

Figure C2-8

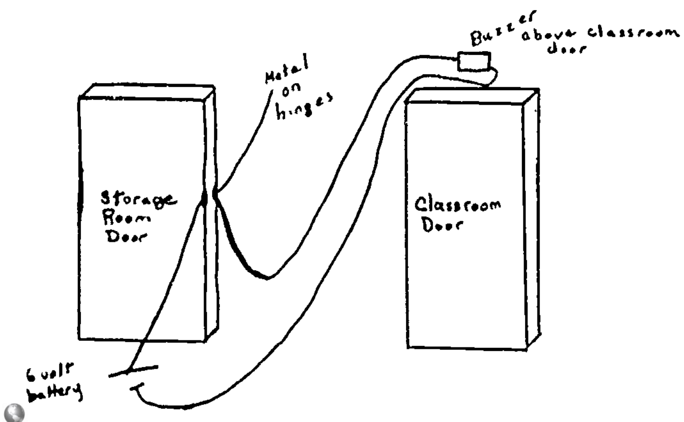


Figure C2-9

6. Order new tools and resupply necessary components.
7. Prevent theft of equipment.

To reduce the waiting time for tools, members of the committee established the rule that a student could use a tool for a maximum of fifteen minutes. They agreed, however, that there might be certain exceptions. Two girls sorted through the Design Lab "How To" Cards and, using an opaque projector to enlarge the illustrations, made posters describing how to use the tools properly.

To prevent loss and theft of tools, the children decided to institute a sign-out system and to keep track of inventory. As a further theft-prevention measure, four boys in the group designed and installed a burglar alarm on the storage room door. They wired the metal on the hinges so that opening the door made the two hinges touch, thus triggering a buzzer in our classroom next door. (See Figure C2-9 for a drawing of their arrangement.)

Vandalism and theft problems in our school forced us to keep most of the tools on a mobile cart as shown in Figure C2-10. When left out in the Design Lab, many tools had been stolen; but kept on the cart, they could be wheeled into the locked storage room and further protected by the newly installed burglar alarm. However, students had difficulty finding the tools quickly because the tools lay in a disorganized pile on the upper tray of the cart. Several members in the Tool Committee took the responsibility for improving this situation.

At first the children thought they would hang up the tools in the lab, but then they realized that although this would make tools easier to find, such action would worsen the theft problem. When their discussion turned to the idea of hanging tools on the cart, one boy suggested using screws to attach plywood sheets to the sides of the cart and hammering in nails on which they could hang the tools. As a refinement of this play, another child recommended using pegboard and hooks in place of plywood and nails. One boy said he chould bring in two large pieces of pegboard that his father no longer needed, and the group then agreed to go ahead with their scheme.

For their preliminary design the children had thought of enclosing all four sides of the cart until they soon realized that this plan would block access to the lower tray. They modified the idea by having a door with a lock as one of the sides, enabling tools to be stored on the bottom tray and locked up at the end of each day. The top tray,

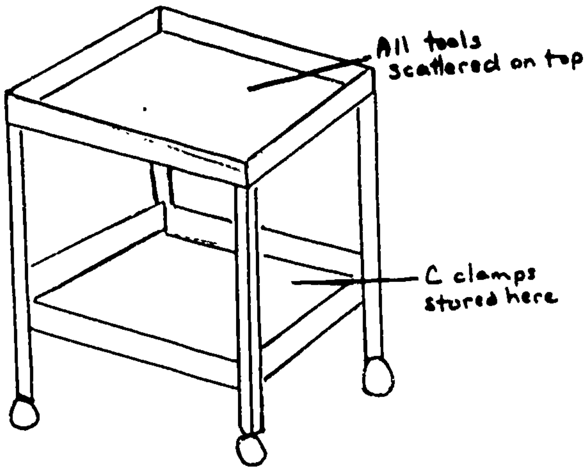
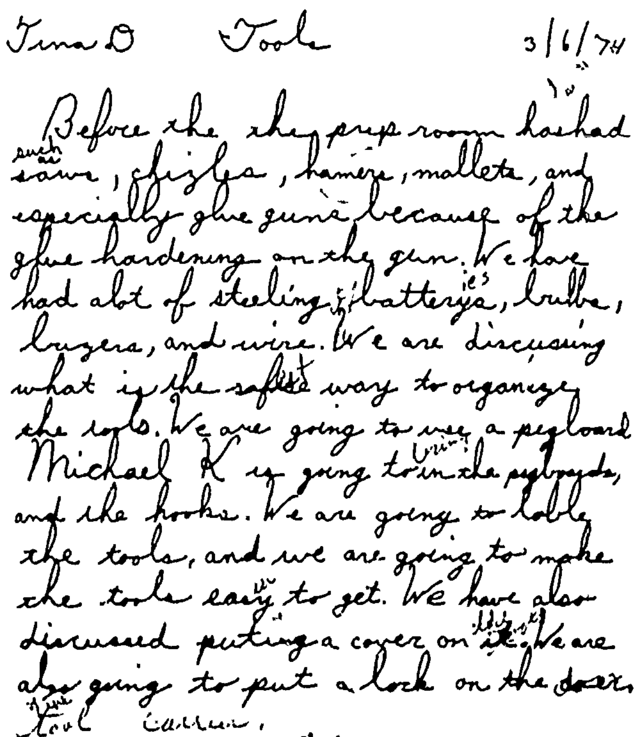


Figure C2-10


Tina D   Tools   3/6/74

Before the shop prep room has had saws, chisels, hamers, mallets, and especially glue guns because of the glue hardening on the gun. We have had alot of steeling of batterys, bulbs, buzzers, and wire. We are discusing what is the safest way to organize the tools. We are going to use a pegboard Michael K is going to in the pegboards, and the hooks. We are going to lable the tools, and we are going to make the tools easy to get. We have also discussed puting a cover on it. We are also going to put a lock on the door, tool carrier.

Figure C2-11

they felt, should serve as a place for heavy tools that would be too dangerous to hang and also as a cooling station for hot glue guns. To protect the tray and to eliminate fire hazards, they planned to line the upper tray with aluminum foil.

Good tool organization, they agreed, should allow students not only to find tools quickly but also to return them easily to their proper places. Labeling the pegboard to show where each tool belonged would do the job, the children decided. Furthermore, because they had more than one of some types of tools (e.g., four hammers), they chose to number those tools and place each number on the corresponding label on the pegboard. (Figure C2-11 shows a copy of one girl's description of the group's plan for the tool carrier.)

Construction began with the children measuring the sides and trays of the cart. The pegboard donor hadn't yet delivered the material, but the children used the waiting time to label the tools with masking tape and markers. When the pegboard arrived, the students measured and cut it to fit the sides of the cart and fixed it in place with screws and washers. During a discussion about whether to use plywood or pegboard for the door, a parent helper mentioned that pegboard warps less easily. Heeding this note, the children measured, cut, and attached the pegboard door. After a few days the screws came loose from the hinges, and the builders attached the door again, this time more securely. The completed mobile tool carrier is illustrated in Figure C2-12.

Although proud of their work, the children continued to improve the cart. For example, one boy worked very hard to install a loud-ringing burglar alarm, spending a lot of time attaching the warning device firmly to the door of the carrier. The alarm worked well.*

*The children might observe other classes working in the lab to determine whether the changes they had made really helped. They might also conduct a survey to find out how others felt about the changes and whether anything else needed to be done.--ED.

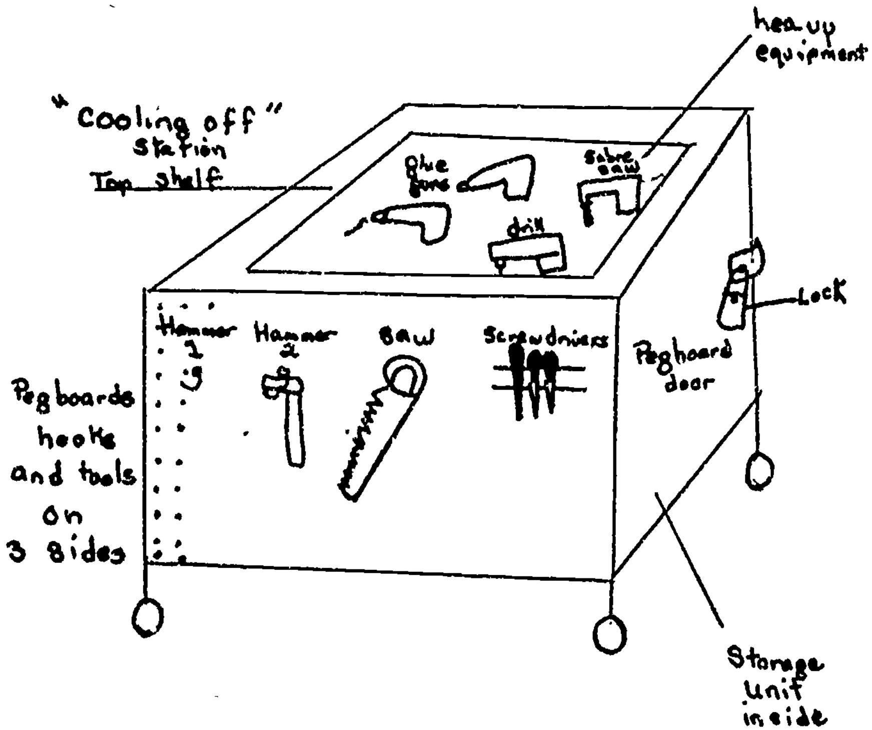

"Cooling off" Station
Top shelf
heat-up equipment
Glue gun
Sabre saw
drill
Lock
Hammer 1
Hammer 2
saw
Screwdrivers
Pegboard door
Pegboards hooks and tools on 3 sides
Storage unit inside

Figure C2-12

3. LOG ON DESIGN LAB DESIGN

by Phyllis Viall Cooper*
Cotuit Elementary School, Grade 4
Cotuit, Massachusetts
(January 1975)

ABSTRACT

While working on the Weather Predictions challenge, this class of fourth graders decided to construct weather instruments. Because their school had no Design Lab, the students switched to Design Lab Design for the month of January and worked daily to modify their classroom for construction activities. Volunteers brought in donated tools and the needed wood was scrounged. Children who had experience using tools helped the inexperienced, and the students also discussed safety precautions. Finding their desks too small and unsturdy, the students decided to build a "workshop," a workbench with storage space. Five volunteers made a composite plan and measured one another to determine a table height that would serve everyone. They purchased materials, altering their plans from one large table to two smaller ones to suit the available sizes of plywood. During construction they confirmed the evenness of their table by checking whether a nail rolled on it and whether water in a glass remained level when placed on the table. When they found that they had built their first table too high for comfortable sawing, the children modified their design for the second table. Nails driven into the crossbeam of one table allowed the class to hang hammers and saws conveniently.

While pursuing the Weather Predictions challenge, my class decided to build weather instruments (wind vanes, barometers, and anemometers). Because our school did not yet have a Design Lab, we faced a Design Lab Design challenge of making our classroom suitable for working with tools.

First, the students compiled the following list of tools and materials required for constructing their weather instruments:

1. wood
2. nails
3. saws
4. hammers
5. screws
6. dowels
7. tape measures

*Edited by USMES staff

Excited by the prospect of building, most children volunteered to bring in some needed items. By the next day we had three saws (including a hacksaw), four hammers, two carpenter's (folding) rulers, sandpaper, nails of various sizes, and a small amount of wood.

The class decided, however, that we couldn't begin construction that day because we didn't have enough wood. Then, while thinking of ways to increase our supply, one boy looked out the window to where additions to our school were being built. He spotted a pile of scrap boards and suggested we ask the construction workers whether we could use their scrap wood. Agreeing that this was an excellent idea, we proceeded outside; the boy who suggested the idea acted as our delegate. He explained our situation to the workmen, who said we could use whatever we wanted from two piles of scrap wood.

Immediately, some children began sorting through the scraps for suitable pieces, while others fetched boxes from our classroom. We soon accumulated three full boxes of wood and spent the remainder of the session sawing it into smaller pieces. The children were ready and eager to begin construction.

Deciding how to distribute the wood in an orderly and fair manner was our first priority at the next session. The class outlined and carried out the following plan:

1. Groups took turns choosing wood. (The class had previously formed groups according to which instruments they planned to build.)

2. Children wrote their names on the pieces they selected.

3. If a child planned to use only part of a piece, he or she marked off that part, enabling another student to use the remainder.

4. Children cut (if necessary) and sanded the pieces.

Next we discussed use of the tools and then, as one child suggested, those students who had experience with hammers and saws demonstrated their skills for those who had never used the tools.

While discussing safety precautions, some children expressed particular concern about using saws; so we listed guidelines:

1. Work where there is good leverage so that there is little danger of losing your balance.

2. Hold the wood so that your fingers are about six inches from the blade of the saw.

3. Have someone help you hold the wood if it slips around.

4. Other children should stand a safe distance from the saw.

For the remaining ten minutes, students worked on their projects and unhappily stopped when time ran out.

The inadequacies of our room became apparent the following day when construction resumed. Several children hammered on the floor because the desks "jumped around." Others grew frustrated by the small size of the desks. In an impromptu discussion of progress and problems, one boy wished he had a bigger table on which to work.

Because we didn't have any larger tables in our room, I asked the class for suggestions. One child offered to bring in an old table from his basement if his mother would let us have it. Although the students liked this idea, they became more excited when one boy said, "Why don't we make our own?" He explained that we could design and build a large wooden workbench with a special place for tools; it could then serve as a workshop for all our projects throughout the year.

When several children expressed interest in making such a workbench, I asked how they would go about it. Make plans, decide on the size, and figure out what materials are needed, suggested one boy. Five children volunteered to draw up a plan for the workbench. As everyone felt we should outfit our workbench with additional materials, six other students agreed to prepare for the class's approval a list of materials to be stocked.

Members of the Plan Group decided to draw up individual designs from which they would take the best parts to form a composite plan. After much discussion they devised the plan shown in Figure C3-1.

To make the table a comfortable height for all, the group had to overcome the problem posed by the widely differing heights. They measured each other to find the distance from the floor to a point between hip and waist and then tried to figure out the "middle of these measurements. When I asked whether they wanted help calculating the average, they said yes.

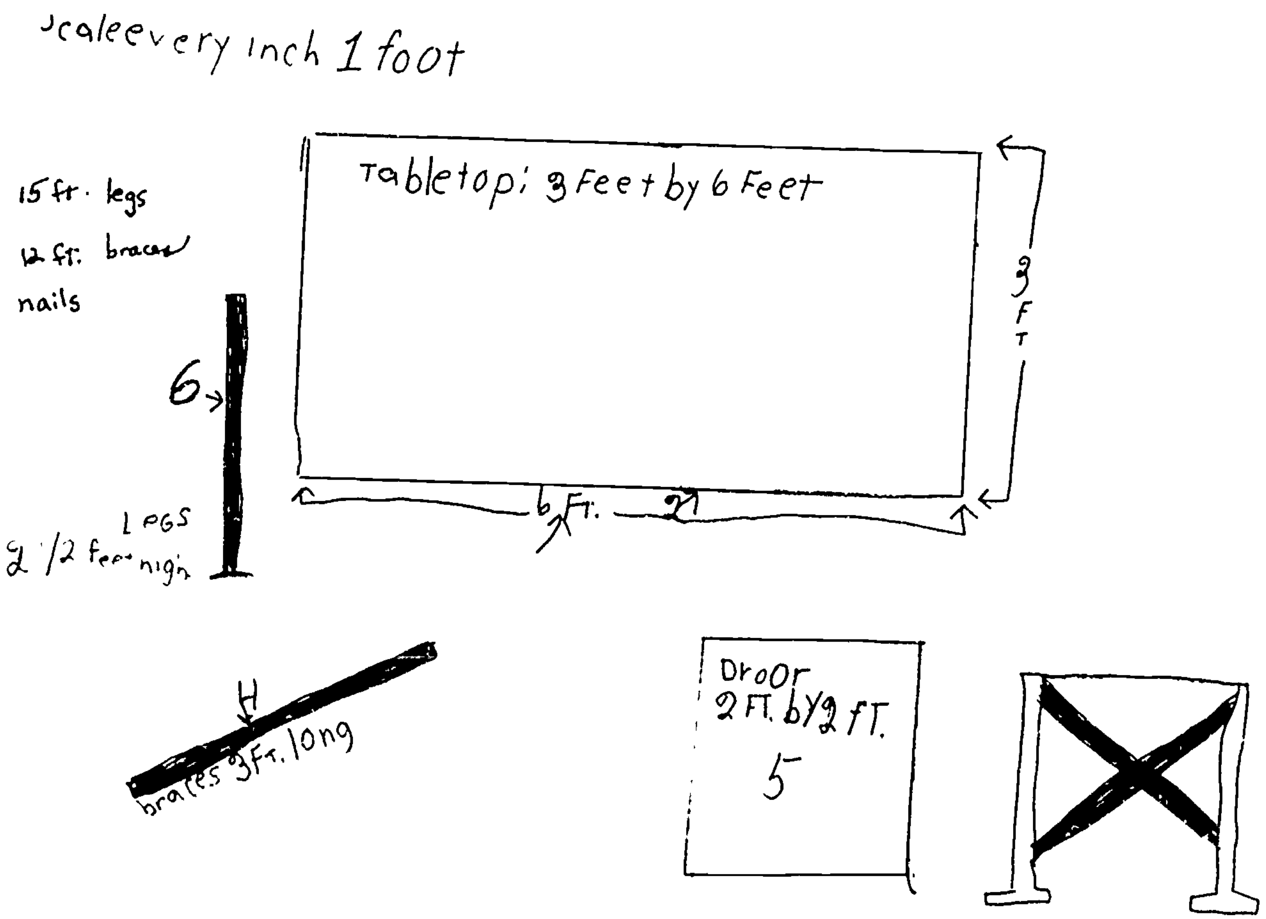


Figure C3-1

We wrote down the five measurements they had made: 42", 40", 33", 34", and 36". They found the sum, 185", and because they had had some previous practice with division, they needed only a little help from me to divide by five to get the average height, 37". They rounded off this figure to 36" to make it easier for them to measure the wood for construction*

They planned a 3 ft. by 6 ft. top surface as a compromise between an area which would fit in the space we had and an area which would allow enough children to work at the table

*The children might have used the median measurement, the middle number in an ordered set of data. The median is quicker to find than the average, and in many cases it is a better number to use.--ED.

simultaneously. To discover exactly how many could work together, they chalked a 3 ft. by 6 ft. rectangle on the floor and asked different numbers of children to stand around the outline and pretend to hammer and saw. Eight children could work comfortably at the table, they decided, but this number would vary because some activities required more space than others.

Meanwhile, the Materials Group made the following list of materials needed for our workshop:

hammers	level	tacks
jigsaw	sander	staple gun
plane	screwdriver	glue (electric glue gun, if possible)
wood	paint brushes	sandpaper
compass	screws	meter sticks
pliers	tape measures	paint
staple remover	electric drill	square
nails	C-clamps	dowels
hand drill	miter box	
electric saw	staples	

When the list was presented to the class, many children said they could contribute some of the items, and I offered to help with tools or materials they had trouble getting.

Of more immediate concern was purchasing the wood and other supplies needed to build the workbench. The obvious source of funds was ruled out because our school prohibited students from raising money for any purpose. While we brainstormed for alternatives, one child asked whether the school might pay for some of our supplies, and I agreed to try that avenue. I submitted an estimate and the school approved.

The designers and I set out on our shopping trip. At the store we discovered that the plywood we wanted came in only two sizes, 4 ft. by 8 ft. or 2 ft. by 4 ft. The children worried about whether the large size would fit in the station wagon and whether 4 ft. by 8 ft. would be too large for our classroom, although once in the room, we could use the jigsaw to trim the size. We might make two 2 ft. by 4 ft. workbenches, suggested one boy, noting that we could use such benches individually or push them together to form one large surface. After accepting this idea, the boys chose two-by-fours for the legs and two-by-threes for braces, both on sale, and they worked out how many pieces their modified design called for. We also purchased nails, another hammer and saw, more sandpaper, and a small plane. The children kept track of how much money we spent (see Figure C3-2).

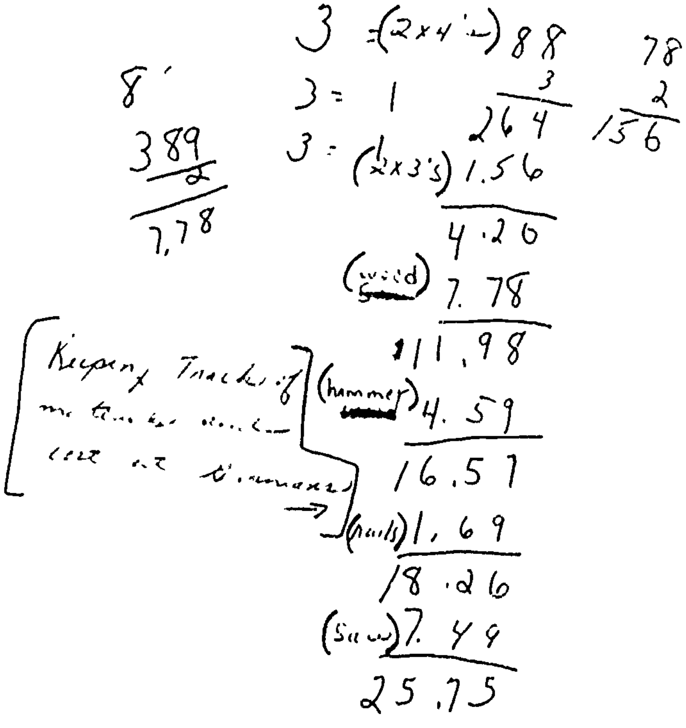
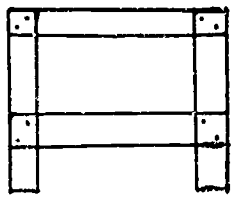


Figure C3-2

The next morning they decided to construct one table at a time, first making all the necessary measurements for the legs. Each time one child made a measurement, another checked it. To simplify sawing, the children balanced the two-by-fours between two desks and then used a handsaw to cut through each piece while helpers held it steady. After sanding the legs, they repeated this sawing procedure with the two-by-threes to prepare the braces, which they nailed to the legs as shown below:



They completed both ends, but before nailing on the top, they checked for evenness. After a visual check showed the table was even, one boy suggested laying a nail on the surface to see whether the nail stayed in one place. It did. For a more accurate test, the children placed on the table a glass of water with even markings. The water remained level. Finally assured that they had a level work surface, they secured the table top to the legs.

Although proud of their work, the children regarded it critically. They decided that it swayed slightly and needed braces on the long sides. I arranged to get the extra wood.

Before starting on the second workbench, the children tried working with different tools at their completed table. It seemed fine, except that the height made it difficult to get the correct leverage for sawing. They redesigned the second table, shortening the legs by six inches.

During the next week, the children completed the second table, added braces on the long sides of both tables, and ended up with two very sturdy workbenches. Some of the builders emphasized that they had learned the importance of accurate measurement.

The class postponed adding a shelf or drawer for tools until we knew just what supplies we could get. At such time, the children decided, they could design and build suitable storage space. Plans changed, however, and the drawer and shelf concepts gave way to a simpler scheme. Some children drove nails into an upper crossbeam on one of the tables, and from these they hung our hammers and saws. We designated one of our small classroom shelves for those tools and materials not suitable for hanging. By June, we boasted the following inventory of mostly donated items:

1. two large handsaws
2. one hacksaw
3. four hammers of varied sizes
4. two planes--one large, one small
5. two folding rulers
6. one steel tape measure
7. one electric jigsaw
8. one hand drill
9. one C-clamp
10. an assortment of nails, screws, and tacks
11. three boxes of scrap wood
12. string, glue, paint, and other extras.

The children were proud of their workshop, particularly when other classes came to see what we had done. They used it not only to construct weather instruments but for other projects as well. For example, when we began investigating the Nature Trails challenge, the children used their workbenches to make and paint wooden signs.

4. LOG ON DESIGN LAB DESIGN

by Margaret Hartzler*
Heatherwood School, Grade 5
Boulder, Colorado
(January - June 1975)

ABSTRACT

This fifth-grade class spent one or two sessions per week on Design Lab Design from January to June. The children first surveyed the students in their school to determine the major Design Lab problems. Based on their bar graphs of the results, they assigned priorities to the various issues, deciding first to work on both the need for more materials and the clean-up problem. To bolster their lab inventory, they suggested obtaining donations and earning money. Each student wrote an advertisement requesting donations, and the class selected the best one for the school newspaper. While waiting for donations, the children worked on the clean-up issue, preparing and placing in the Design Lab posters that reminded lab users to clean up. The students obtained the principal's approval for an "everything" sale, which combined many of their sale ideas into one affair. To secure donations of sale items and to ensure good attendance, they launched an advertising campaign and held a successful, six-hour, Saturday sale--netting eighty dollars. They allocated their profit in accordance with the Design Lab manager's list of needed items, but because the school year was nearing an end, they postponed purchasing the tools and materials until the following fall. They also prepared plans for a "touch-and-feel" box that would sufficiently interest children who might otherwise handle other people's project left in the lab.

I introduced the challenge to my fifth-grade class with some questions about the Design Lab: How had the students used the lab? What tools were available? What problems did they have using it? Students pointed out the following Design Lab problems:

1. can't use certain tools without supervision
2. clean-up
3. finding materials
4. need more equipment
5. scheduling use of the lab

*Edited by USMES staff

6. safety
7. safe places to store projects
8. more materials.

I asked the students whether they wanted to try to solve some of these problems and they said yes. However, they felt that before making any changes in the lab, they should consult the rest of the school to find out which problems other children considered most important. They suggested the following three ways to do this:

1. For each grade, put a suggestion box with the list of problems attached (or read the list to all the classes). Then ask the students to write down and place in the box the problem they consider most important.

2. Two or three children go to each grade, read the list of problems, and take a vote.

3. Post the list of problems on signs around the school and give children a questionnaire to fill out.

By vote, the students chose the second suggestion, and after some discussion they decided to work in pairs, with each pair of students responsible for surveying two classes. After one child mentioned that some classes never used the Design Lab, we agreed not to interview those classes.

Planning a time to take the survey raised some problems. One child recommended that we go to the classes immediately, but others, thinking that this might annoy teachers, suggested making appointments. Another student pointed out however, that interrupting classes to make appointments might also annoy teachers. After the children tried unsuccessfully to determine a good time to talk to teachers outside of classes, I reminded them about teacher mailboxes. The students hadn't realized that these mailboxes could be used for anything other than regular mail. Pleased with the suggestion, the class spent the rest of the period composing a request for an appointment.

Within a week most of the replies had been returned and the children had surveyed the classes at the appointed times. Because we had excluded classes that didn't use the lab, we had results from about half the classes in the school.

To begin our data analysis, one girl suggested that we put all our totals together. Two boys compiled the results at the chalkboard. At first, they wrote the numbers anywhere, but after they had to add the totals for the first question, they subsequently formed two neat columns for yes and no responses. The questions and totals are shown below:

	Yes	No
1. Is it a problem when you have to wait a long time to use a tool because Mrs. Jordan [the Design Lab manager] has to watch?	133	60
2. Is it a problem with people not cleaning up?	139	48
3. Is it hard to find things that are there?	82	99
4. Can you usually use the Design Lab when you want it?	83	79
5. Are people getting hurt using the Design Lab?	39	196
6. Do we need more and different kinds of tools?	110	57
7. Do your projects get ruined by others?	128	109
8. Do we need more materials to work with?	156	57

Examining the figures for each question, the class was surprised that some of the problems they had considered serious, others had not. When the children didn't seem to have any ideas about how to determine which items really were problems and which weren't, I asked whether anyone knew how to draw a graph to make a picture of the data. One girl went to the board and drew a bar graph representing the results of two survey questions. Following her examples, the class worked in pairs to show all our results in graph form. To bolster the skills of the students who hadn't grasped the concept, I held a small graphing session in one part of the room.

Because the graph paper did not contain enough squares [illegible] llow one square to equal one vote, the children had to

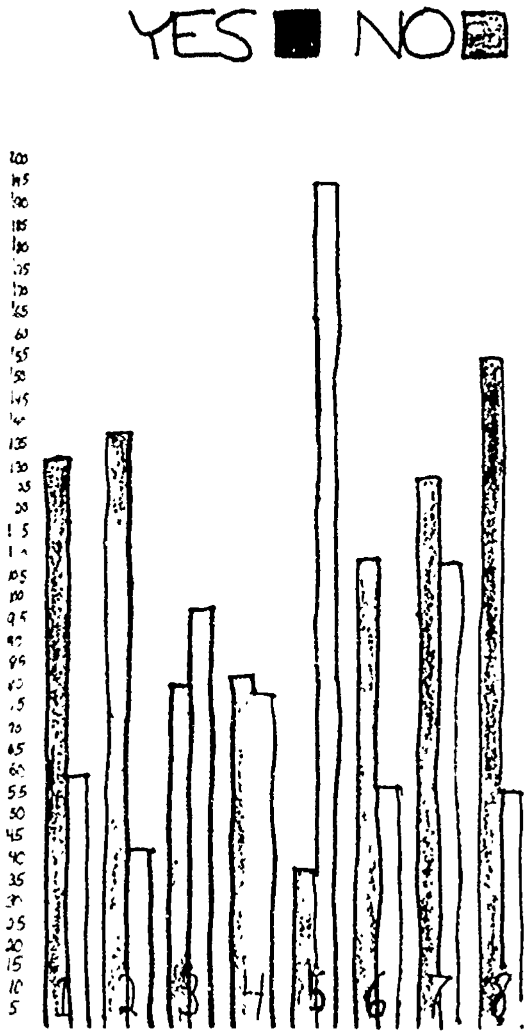


Figure C4-1

figure out how to fit 200 votes on the paper. Most let one square represent five votes; then to show numbers not divisible by five, they either divided a square into five parts or else wrote the remainder beside the bar. Other children attached several sheets of paper to form a large graph 200 squares high. One pair calculated the percentage of yes and no responses for each question and graphed these instead of the totals.*

Every pair of students made a bar graph (see one example in Figure C4-1) although we discussed other types as well. The class listened to an explanation of every graph and then enumerated the elements of a good graph. Children pointed out the importance of--

1. having the yes and no columns for each question next to each other
2. using two colors (no more, no less): one color for yes, one for no
3. putting a title and explanation or key on the graph.

Next, the students voted on which graph to use for the class discussion about priorities of the problems on their survey.

Because problems 3, 4, and 5 on their survey hadn't received many affirmative votes, the children decided we didn't need to work on them. However, some felt that problem 4--with slightly more yes than no votes--deserved our attention after we had dealt with the more serious issues. The students assigned top priority to problems 8 (need for more materials) and 2 (cleaning up), in that order, and planned to work on both simultaneously, postponing problems 1, 6, and 7 until they had solved the two major ones.

When we discussed ways to build up the supplies inventory in the Design Lab, the children suggested getting donations and earning money. Their fund-raising ideas included--

collect aluminum cans	Easter egg hunt
bake sale	fun fair
garage sale	car wash
odd jobs (mowing lawns, etc.)	raffle

*The children might discuss whether using percentages rather than totals of responses offers a better means of comparing the questions when the number of votes for the different questions vary. Younger children can draw a slope diagram rather than calculating percentages.--ED.

put on a play	catch and sell frogs
publish and sell a newspaper	a dance
collect bottles	pet grooming
baby-sitting service	pet show
	plant sale

Although holding a fun fair received the most votes, our principal vetoed the idea because older children had caused problems at such functions in the past. Nor did he give permission when the children offered to schedule the affair on a school day at noon instead of on a weekend to avoid vandalism problems.

This setback dampened the students' enthusiasm for earning money, and we returned to getting materials donated. The children wrote advertisements requesting donations for the lab, and the class selected the best ad for the school newspaper. One student thought of placing a box for donations in the school lobby, and we received the principal's approval for this idea.

While waiting for donations, we reviewed our survey results and decided to start work on the second priority issue--cleaning up. Many children felt it was unfair to have to clean up the mess created by others. Most suggestions incorporated some form of policing, requiring my students to perform a lot of time-consuming and unproductive work. Other recommendations included the following:

1. Have a clean-up detail come in after school.
2. Designate a time each week that would be used by the class to make repairs on broken equipment.
3. Devise a sign-up method for using the Design Lab and check the room before people can sign out.
4. Select a class delegate who would issue a clean-up warning five minutes before class ends.
5. Make tape-recorded messages to be played in the Design Lab reminding students to clean up.
6. Put up artistic posters for reminders.

The children decided to invite the Design Lab manager to come to class to discuss these and other ways of solving the clean-up problem. In the meantime, they began making posters reminding lab users to clean up before leaving.

Degrees of planning varied considerably among the poster [illegible] with some working individually, some in pairs. Most children made no formal plans. Once they thought up a slogan, they immediately wrote it on the construction paper they would use as the poster. Then, when they made mistakes or noticed that they didn't leave enough space for their words, they simply turned over the sheet and began again after making proper adjustments.

In contrast, one pair of boys sketched a large trash can on scrap paper before drawing on the poster. The boys wanted their picture to fill the space left by two-inch side margins and an eight-inch top margin for the slogan. On construction paper, they measured the allotted space, enlarged their sketch accordingly, cut out the model, and placed it on the construction paper for a visual perspective. Pleased with the appearange, they traced around the cutout and commenced coloring a final version.

With similar care, a pair of girls prepared a poster based on the slogan, "To Clean Up or Not to Clean Up Is the Question. Clean Up Now Is the Answer." The girls wrote these catchwords on scrap paper and counted the letters. After measuring their sheet of construction paper, they discussed letter sizes and decided to try two-inch letters. From scrap paper, they cut out a sample 2 in. by 2 in. letter and moved it across the construction paper to see whether their slogan would fit. Determining that each line could contain only ten letters of that size, they tried smaller letters until they had a pleasing layout. The class completed the posters, hung them in the Design Lab, and turned their attention once again to fund raising.

Good money-raising projects, according to the class, should incorporate these elements:

1. something people will enjoy and support
2. an idea that will make the most money
3. an idea that will be fun to do

An "everything" sale, combining many of their previous sale ideas, fit the requirements. "Everything" meant plants, pets, baked goods, fish bait, crafts, and anything else they could get. Because there were so many volunteers who wanted to ask the principal for permission, we made the selection by pulling three names from a hat. The chosen three spent a few minutes in preparation and then succeeded in obtaining approval.

The class scheduled the sale for Saturday, April 26, from 10:30 A.M. to 4:30 P.M., with set-up time beginning at 9:30. Each child wrote a note to his or her parents requesting permission to work at the sale for one of four

Dear Parents Tammy [illegible]

On Saturday April 26 our class is having an "Everything Sale" to raise money for materials for the design lab.

We need to know if ______ can work at the sale and what time would be best. Please check your first and second choice for working times. We also will need everyone who can be here from 9:30 to 10:30 to help set things up.

Thank you!

10:30 - 12:00 ____
12:00 - 1:30 ____
1:30 - 3:00 ____
3:00 - 4:30 ____

Signature ______________

Figure C4-2

ninety-minute shifts and for the set-up hour. (Figure C4-2 shows a copy of one student's letter.)

Next, the class made preliminary plans for advertising our sale. They decided that an article for the school newspaper, combined with posters in the halls and an intercom announcement as a last-minute reminder would be sufficient. In a lengthy discussion about types of posters, the students decided to make a wide variety of neatly prepared, eye-catching signs.

During the next two weeks, however, advertising plans were expanded. One group prepared a sandwich sign by cutting a large sheet of cardboard in half and attaching the halves with shoulder straps made from rope. They planned to have one child wear the sign which listed the date, time, and place of the sale along with sale items.

The group decorating the donation box chose to add an element of suspense to our advertising campaign. They decided to make huge footprints and attach them to the floor leading to the intended location of the box. At that site they would place a sign reading, "Something Will Be Here Next Week. Watch For Its Appearance."

One girl pointed out the possibility of gaps in our advertising campaign, noting that many children often took home the school newspaper without reading it. To make sure we reached everyone, four girls drew up a schedule for a pair of students to visit all classes to announce our need for donated items for the upcoming event.

When some posters had been completed, the children discussed where to place them for the maximum effect and suggested these spots:

1. the door to the gym
2. the front door
3. traffic areas
4. cafeteria
5. drinking fountains
6. office
7. pit area near the school store

Their posters incorporated clever ideas designed to attract attention and convey information. For example, in some, flip-up windows revealed pertinent data about the sale; in others, accordion-like decorations added a three-dimensional touch (see Figure C4-3). A poster committee selected two posters for display at a local supermarket. Before choosing, the groups had decided that students who didn't want their posters so displayed did not have to submit them.


"Everything Sale"
April 26-Saturday It will
be from 10:30 to 3:30 p.m.
There will be plants, Goodies to
eat, fish bait, Gerbils, hamsters, etc.
Crafts, and Garage Sale items.
THANK-YOU

Figure C4-3

9:30 - 10:30 Anybody

10:30 - 12:00
Peggy Diane B, ~~[illegible]~~
Michelle, Sandy Jenny
Valerie, Dianne

12:00 - 1:30
Leslie, Vicki
Gabby, ~~[illegible]~~ Scott
JeffA, Kim

1:30 - 3:00
Gary, Valerie
Dianne, Sandy
Sharrie Todd
Donna, Debbie

3:00 - 4:30
Tammy Ann
Gary, Heather
StanB, Kim

Figure C4-4

Organizational tasks also required our attention. Because we could not enter the school building on the sale day, we had to decide where to store our sale items. Fortunately, the family of one of the girls who lived near school offered to let us use their garage. We next set up a schedule for workers. Some students volunteered to work two shifts to compensate for those who couldn't come. (Figure C4-4 shows a copy of the students' sign-up sheet for the different work shifts.)

During these weeks leading up to the sale, children kept records of our progress, checking off tasks as we accomplished them (see Figure C4-5). By the Wednesday before the sale, people had begun bringing in donations, and we were ready to begin pricing them.

I grabbed a sack and we priced its contents item by item, discussing how to determine the worth of an object. Then the class split into groups, each taking a batch of donations, some tape, and markers. I told the members of each group that they had to agree on prices; each decision was theirs. They had a lot of fun and by Saturday they had priced every item.

On the day of the sale, early-bird shoppers made setting up quite hectic, but we had great success. Our assortment of animals--two rabbits, five gerbils, four hamsters, one guinea pig, and a bowl of guppies--made quite an attraction. Although the gerbil bit one girl and the first two buyers of the guinea pig returned it, all the pets wound up in the hands of paying customers. We also managed to unload our unsold items productively on a group of girls planning a sale to benefit cancer research. Our "everything" sale delighted the class, especially the eighty dollars we earned to boost the Design Lab inventory.

Three sessions after the sale, we began to make some progress deciding how to allocate the profits. Our Design Lab manager prepared a list of needed tools and materials, and two children priced each item, lost their list, and priced again. After trying to determine which items to buy and which to forego, one student suggested that we simply go through the list, estimating a quantity for each item, adding the costs, and seeing how close we were to our eighty-dollar limit. Following the child's advice, we found we could buy some of everything on the list and still have almost ten dollars left (see Figure C4-6). We then added a little here and there until we had used up our funds.

Buy now or later?--that was our question. The class had hoped our Design Lab manager would do the shopping, but her

Posters
Put up finished
Finish + Tammy, Kim, Leslie, Sharre, Jeff, Jeff, Doug, Stan, Gary, Todd, Diane, David, John, Mark
Choose 2 for K Soopers

Place for donations
Sign-Ann, Scott Donna
Rearrange Michelle, Billy, Gabby, Mark, Diane, Debbie

Sandwich Man - Gary, Stan B

~~Monday~~ Wednesday talks Sharrie, Heather, Dianne, J[illegible]

Adervertising
Intercom - Tammy - Valerie
Boy Stan, Mike, Todd, David, Sandy, Peggy

Figure C4-5

[illegible]
paint [illegible] 84
glue sticks 12 per 78¢ (5) 490
power saw [illegible] 98¢ to 198 [illegible] 500
goggles [illegible] 770
wood (4 x 8) 471 per [illegible] $958
furring strips 17¢ each - 6 ft (15) $285
[illegible]
hammers to 99 to 15 00 (2 [illegible]) 741
[illegible] 110 to 99 597
nails [illegible] pound [illegible]
[illegible] pound [illegible]
[illegible] 193 (3) 497
-72 54 dollars

Figure C4-6

time for the year had expired. This also meant that the lab would see only about one-third of its normal use, lessening the immediancy for action. Wood might warp during the summer, noted one student, who favored postponing the purchases until September. By vote, the class agreed to wait until fall.

Time remained to make some progress on other Design Lab problems. Discussions about how to prevent students from ruining other children's projects evoked two major ideas:

1. Go to each class and give a program or demonstration to encourage students to leave alone the projects of others. (We shelved this idea because not enough time remained to develop and implement it.)

2. Make a "touch-and-feel" box based on the premise that would-be "fiddlers" would tamper with the box instead of with other people's projects.

About ten volunteers started work on the box, but after their first discussion they realized they would not have time to complete the project. Instead, they chose to attempt to complete only the planning phase, with hopes that their next-year teachers would give them time for construction. Several members of the group had similar concepts of the box: it would contain various compartments, each with a rubber or plastic opening, resembling those on garbage disposals. Students could stick their hands in the hidden compartments and touch such good-feeling things as playdough, sand, and furry fabric. The students' plan included decorating the box and placing on it a slogan encouraging children to feel inside instead of touching other people's projects.

5. LOG ON DESIGN LAB DESIGN

by Janet Sitter*
Michigan Avenue Middle School,
Grade 5
Howell, Michigan
(September-October 1975)

ABSTRACT

For the first two months of the school year, these twenty-seven fifth graders spent approximately four hours per week setting up a Design Lab for their school. Attracted on the first day of school by two study carrels that had been built by a former class, the students were immediately interested in organizing a work area in which to build things. In order to have the Design Lab ready as soon as possible, their teacher had done some of the preliminary work, such as conferring with the principal, seeking out an unused room, and investigating how much money was available for Design Lab supplies. After touring the designated lab room, which was filled with stored items, the students discussed its good and bad features and then listed their major concerns about setting up the lab (e.g., cleaning the room, obtaining supplies and equipment, spending their money wisely, planning for safety procedures). They decided first to work as an entire class on the problem of obtaining tools. Many materials were secured through parent donations, and the students sought and obtained advice on what to purchase from the art teacher, the high school shop teacher, the Design Lab manager at a nearby school, and the USMES Design Lab coordinator. The class refined their preliminary inventory list into a $200 order for the most necessary items. Next, the students cleaned out the room, devised a suitable furniture layout, and made posters on safety rules. As the scrounged and purchased materials came in, a group checked the items against their inventory list and marked the tools with an electric marker. The last major task was to formulate procedures for using the lab. These included rules for advance notice, adult supervision, and maximum number of students allowed in the lab at one time. The Design Lab was opened for school use approximately seven weeks after the class first began to plan for it.

A pair of two-story study modules caught the attention of my class on the first day of school. The children wanted to know what they were, how they got there, and who had made them. I explained that my students from the previous year

*Edited by USMES staff

had built the carrels to improve the classroom, but I pointed out that the construction noise, especially hammering and sawing, had disturbed neighboring classrooms.

"Wouldn't it be great," I asked, "if we could set up some kind of room in this school as a shop to work and build things in, instead of having to do it in the classroom?"

Instantly, the children agreed, letting go with a series of questions. "Is a room available?"

"Will we be allowed to do it?"

"What do we have to put in the room?"

I had already spoken with the principal and took the opportunity to bring the class up-to-date. The principal, I told them, had said a room was available, and she had given the green light to begin planning the setup for a Design Lab. I mentioned that although there was some USMES money available for supplies, many things would have to be obtained by the class. (Ordinarily, I would have let the children find out all this information directly from the principal, but I had interceded to speed things up. I hoped to have the Design Lab in operation on a limited scale by October first and on a full scale by the beginning of November.

After our discussion, I asked the students whether they wanted the challenge of setting up a Design Lab. They were enthusiastically in favor of it and immediately began volunteering to bring in items for the lab. "That should come later," interrupted one boy. "First we should look at the room to see what's available." The rest of the class agreed and the session came to an end.

Before going to the would-be lab room at the start of the next session, the children suggested things to check: electrical outlets, storage space, chalkboards, tables, desks, lighting, and room size. With these in mind, the students set out. Arriving at the lab, the youngsters saw that the room was being used for storage; it was filled with desks, boxes, and books discarded from classrooms and offices. These were all examined by the children, as were the cupboards, closets, and corners of the room.

Back in our classroom, we discussed the advantages and disadvantages of using the room as a Design Lab and made the following lists on the board:

Advantages	Disadvantages
Lots of cabinets	Only 2 electrical outlets, both near the door
Lots of desks	Room is small
Three chalkboards	No sink or running water
Good lighting	Low ceiling
Lots of drawers	Security problem
Separate room for storage	
One wooden workbench	
Lots of cupboards	
Many shelves	

Students gave reasons for each item they put on the "Advantages" list. The chalkboards, for example, were good because they provided a place where the lab users could draw or display construction plans. A separate adjoining storage room (actually a large closet) was envisioned as a place to keep large supplies like cardboard and wood. Everyone disagreed that the wooden workbench was an advantage, but the students did debate the usefulness of the desks, eventually deciding that they would not work well for cutting, sawing, drilling, and other construction. Someone pointed out, however, that the large, long counter running the length of one wall would be useful.

The children also elaborated on the disadvantages of the room. Two outlets, they believed, were insufficient for the number of power tools they would need. Furthermore, because the outlets were near the door, people entering the lab might trip over power cords. The first-floor location of the room, with windows accessible to thieves or vandals, might present a security problem. The low ceiling could also be considered a disadvantage because large items, such as the two-story study modules, could not stand vertically. Nor would they fit through the rather narrow door, one child observed. Another student suggested that such projects could be built in parts or sections and then assembled in a classroom.

During this discussion, the possibility that noise would disturb classes near the lab arose. One student had noticed that the walls were panelled. When I asked whether that would be an advantage or a disadvantage, he replied, "Well, that's what I don't know--whether the panelling would make the room noisier or quieter."

Most of the students were sure that acoustical tiles, which they called "ceilings with holes in them," cut down noise in a room. The session ended and the matter was dropped.*

The class finally decided that although the room was small--compared to a classroom--it would serve well for a Design Lab because the storage areas allowed the entire floor space to function as a work area.

The next day we discussed our concerns about setting up the lab. The following items were listed:

1. Money for purchasing tools.
2. Where to put stuff we want moved out.
3. How to spend the money wisely: what is the best value?
4. Which stores to get tools from.
5. What to do with the space.
6. How to clean up the room.
7. How to arrange the tools.
8. What tools do we need?
9. How can we make the Design Lab safe from theft?
10. Where do we get the supplies?
11. How, when, where do we get tools? Who should get them?
12. How many people can work in the lab at one time?
13. How can we get more electric outlets?
14. How can we make sure people don't get hurt?
15. How can we get a sink?

As we looked over the list, we tried to figure out which concerns should be dealt with first. Two of the boys came up with these suggestions on how we should proceed:

#1	#2
1. Get tools and equipment	1. Know what we're going to buy and how much it will cost.
2. Get money.	2. Raise money.
3. Clean out room.	3. Clean out room.
4. Plan ahead.	4. Buy tools.

*If the noise level did prove to be a problem after the lab was set up, the class might investigate ways to muffle the sounds. See the mini-log by Sandra Baden in the Classroom Management Teacher Resource Book.--ED.

However, the children could reach no agreement about these alternative sets of priorities. There were also arguments about whether to break up into small groups or to work as a large group. Finally, one child's suggestion pleased everyone: "We should all plan what tools we'll need and what we're going to buy. Then we can have small groups and figure out how much and where to buy. A small group can clean out the room and another small group can start purchasing materials." As the class ended, I asked the children to start thinking about how we could find out what to buy for the lab, so that we wouldn't have to rely on guesswork.

On Monday the children came in with ideas on how to get help in selecting the lab inventory. I listed their ideas on the board:

1. Ask fathers.
2. Ask art teacher.
3. Ask at hardware store.
4. Ask at lumber yard.
5. Ask a builder
6. Ask the class that built the study modules.
7. Ask someone who has a Design Lab.
8. Ask a high school shop teacher.
9. Ask custodians.

I added a suggestion of my own--ask the Design Lab Coordinator for USMES. I explained that the coordinator was a staff member of the USMES Project in Massachusetts.

The children organized the list and decided how to go about reaching the different people. They felt that fathers, hardware store owners, lumberyard owners, and builders could best be asked via official letters on school stationery. They decided to telephone the USMES Design Lab Coordinator, the high school shop teacher, and the lab manager of the Allen Street School, a nearby school with a functioning USMES Design Lab. The art teacher and the custodians would be interviewed in person. The class then decided who would carry out each task at our next session. Children who didn't have specific interviewing jobs checked the Yellow Pages of the telephone directory and compiled a list of hardware stores, lumberyards, dime stores, discount houses, and electronic supply stores.

Reports of the interviews were presented the next day. The Design Lab Coordinator at USMES agreed to send a list of suggested Design Lab supplies, and he asked to be kept informed of what we were doing. The Design Lab manager for the Allen Street School said that she would mail a list of their lab inventory. The high school shop teacher also agreed to make a list of all shop supplies, and she mentioned that some of the saws and other tools in her shop really belonged to our school. The art teacher said that all the tools in the art room belonged to the art department and could not be stored in the Design Lab but that we could borrow them when we needed to, provided they were returned to the art room. She, too, agreed to make a list of what she had. The custodian, who was asked for a list of his tools, said that it would be easier for him if we would provide a list of what we needed so that he could check off the items he had.

During the next few days, as we waited for the promised lists, we started to learn more about tools. I distributed copies of the inventory list in the USMES *Design Lab Manual*, and we talked about what the tools were and what they were used for. When we came across the name of a tool we didn't recognize, we looked through copies of the Sears Catalog to find a description or a picture.

During this interim period, scrounging also began. The official letter to parents that the students had suggested was drafted by the principal. Although the children raised some minor criticisms--such as saying that "the sophistication of the lab is not high"--the letter went out as written.

The letter brought amazing results. When we regarded the display of materials and tools that had been donated, we found an impressive group of items: a hacksaw, a used drill, a brand-new drill, drill bits, a level, three six-foot folding rules, three hammers, wire, wrenches, a soldering iron, batteries, a handsaw, pliers, screws, nails, marking pens, transparent tape, and marbles.

When the inventory list came from the Allen Street School, one boy read off the items while the students checked them off on their individual inventory lists from the USMES *Design Lab Manual*. As the other lists arrived, we did a similar cross-checking, reasoning that those items appearing on all four lists were likely to be the most necessary.

Next, we were ready to study the Sears Catalog to see what we would purchase, but we ran into tremendous difficulties. We found that we had eight catalogs--all different. Some of them were for summer, some for the previous fall and winter; some were for this year, some for last year. We discovered huge discrepancies in prices, item numbers, and page references. That afternoon, I went to the local Sears Store and obtained fifteen current hand tool catalogs, one for each two students.

In our next session, each student was assigned one particular tool from the inventory list with the responsibility for recording the page number on which it was located, the catalog number, and the price. As we compiled our findings, we sometimes had to make decisions between two similar items. For example, there were two crosscut saws, a Craftsman for $9.95 and another brand for $2.95. The students argued for a while over which was a better purchase, the one with the Craftsman guarantee or the cheaper model. Finally, one boy's logic prevailed. "If we take the one that's cheaper," he said, "even if we break it, we can replace it twice before we reach the $9.95 that the Craftsman costs."

We were faced with a similar dilemma for other items. Most of the students opted for the cheaper items until we reread the USMES Coordinator's advice against purchasing cheap tools. The class thought it over and decided to stick with the guaranteed tools, except when a cheaper brand offered a substantial discount.

After hours of research, we were ready to total our tentative order. Working in groups of three or four students, we began to add up the prices, a few at a time. I found that several students had trouble in calculating the sum of a column of numbers, as, for example--

$$
\begin{array}{r}
\$\ 4.79 \\
9.90 \\
5.77 \\
1.19 \\
9.97 \\
\hline
\end{array}
$$

For the first few problems, hardly anyone in the group had the same answer as I did, and so we stopped to have a short review lesson on addition with decimals. As we proceeded, more and more students became accurate in their addition.

When we finally computed the grand total, the students were staggered to find out that the order was about $614, and this did not even include such items as Tri-Wall, nails, lumber, a saber saw, or safety goggles.

The students quickly realized that they would have to choose their items very carefully. We decided to limit our first order to no more than $200.

The next day, the students prepared individual lists of items, taking into consideration the cost, the minimum number of tools they would need to open the lab, and which tools could wait until a second order. Their goal was to order as many necessary tools as possible and still stay

Circled number is price 1

		200.00
1	Drill set	= 16.99
		183.01
2.	1 pair longnose pliers	2.97
		180.04
3.	1 pair heavy duty screwdrivers	2.87
		177.17
4	1 Knife set	-4.95
		172.22
5	1 electric glue gun	10.77
		161.45
5	Glue for gun	2.94
		158.51
6	Vice grips	-6.95
		151.56
7	Hand drill	3.95
		147.61
8	2 Bench vises	-49.99
		97.62
9	10 Pencil compasses	3.90
		93.72
10	12 scotch tape	9.80
		83.92
11	1000 Paper clips	.35
		83.57
12	8 pr. scissors	16.80
		71.77
13	20 sheets lag board	18.80
		52.97
14	2 stop watches	15.50
		37.47
15	6 Hand Mirrors	7.50
		29.97
16	1 can opener	-1.00
		28.97
17	1 cross cut handsaw	2.95
		26.02
18	1000 ft of no. 22 plastic wire	15.00
		11.02
19	Pack sabre saw blades	- 5.99
		5.03 for tax

Figure C5-1

within $200. As they did their figuring, most students started with $200 and subtracted prices successively until they reached a point where little or no money remained. Figure C5-1 shows one student's calculations. After purchasing various quantities of 19 items, she was left with $5.03, which she designated for tax.

During the following session, we worked together to tally the number of times each tool had appeared on a student inventory list to determine which tools the class felt were most important. The results were listed on the board as follows:

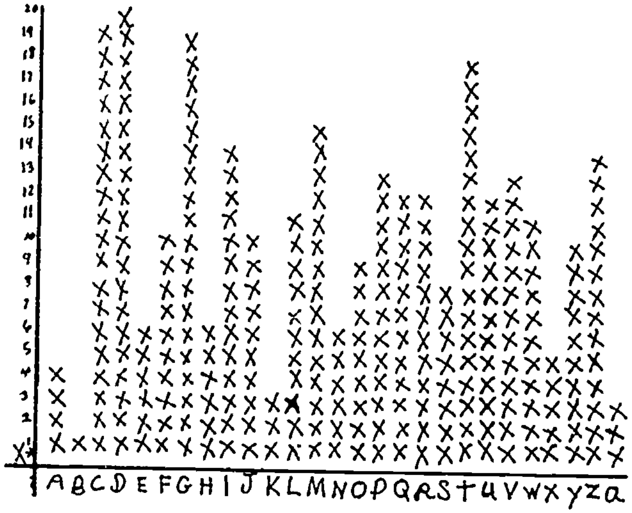
combination squares	5
folding rules	1
crosscut handsaw	19
drill set	20
saber saw	6
saber saw blades	10
25-ft. extension cord	19
sawhorse brackets	6
regular screwdriver sets	14
Phillips screwdriver sets	10
hacksaw blades	3
wood chisels	11
slip-joint pliers	15
linemans pliers	6
cutting pliers	9
long nose pliers	13
heavy-duty screwdriver set	12
wrench	12
utility knife	8
glue gun	18
glue sticks	12
coping saw	13
coping saw blades	11
putty knife	5
vice grips	10
hand drill	14
solder gun	3
black plane	9
6" C-clamps	12
2" C-clamps	2
spirit level	7
tape measure	15
bench vise	14
50-ft. tape measure	10

white glue	|||	3
round file	|	1
16 oz. claw hammer	~~||||~~ ~~||||~~ ||	12
13 oz. claw hammer	~~||||~~ ||||	9
5 oz. claw hammer	~~||||~~ ||||	9
safety goggles	~~||||~~ ~~||||~~ ||	12

When questioned about the difference in votes for saber saw and saw blades and for hot glue gun and glue sticks, the students responded, "We thought we could buy the extra blades and glue sticks later. Right now we could get along with the least we can."

The next day we looked at the results, eliminated items that had been donated, and tried to put together our order. The total came to $181.36. Next, we projected a second order for Tri-Wall ($100) and bench vises ($50). We also hoped to have $50 in reserve for special requests. Meanwhile, one of the students telephoned the order to Sears and then reported that it would be ready in a few days. The class was delighted.

We had a shortened period the next day, and so we decided to look at the data we had collected on the number of students who had chosen each tool. We started to talk about how to display the data, and because the class had already done bar graphs for other units, that was the immediate suggestion. We each made one (see Figure C5-2).*



A= comb. square
B= fold. rule
C= c/e hand saw
D= drill set
E= sabre saw
F= s/s blades
G= 25 ft ext cord
H= sawhorse brackets
i= s/d set
J= phil s/d set
K= h/s blades
L= wood chisels
M= slip joint pliers
N= lineman's pliers
O= cutting pliers
P= long nose pliers
Q= heavy duty s/d
R= wrench
S= utility knife
T= glue gun
U= glue sticks
V= coping saw
W= c/s blades
X= putty knife
Y= vice grips
Z= hand drill
a= soldering gun
b=

Figure C5-2

Just about a month had passed since we had first started to think about planning the Design Lab, and now we were ready to start setting it up. One of the girls had asked the custodian if he wanted help in hauling away the furniture and other things that we did not want to use. He replied that he could use the help of four or five children to load the items on a truck. This had been done, and once the room was cleared, we realized that there was much more space than we had originally thought.

We had assembled a good collection of usable furniture. Both custodians and teachers had been helpful in offering to donate tables. Now it was time to figure out how to make a workable area.

We discussed the purpose of a floor plan and how to draw one. Then, armed with paper and pencils, the entire class went to the lab. While most of the students drew their individual proposals for arranging furniture, a small group

*The class might have made the bar graphs first, before ordering the inventory. The graphs could have shown them directly which items were preferred by most students.--ED.

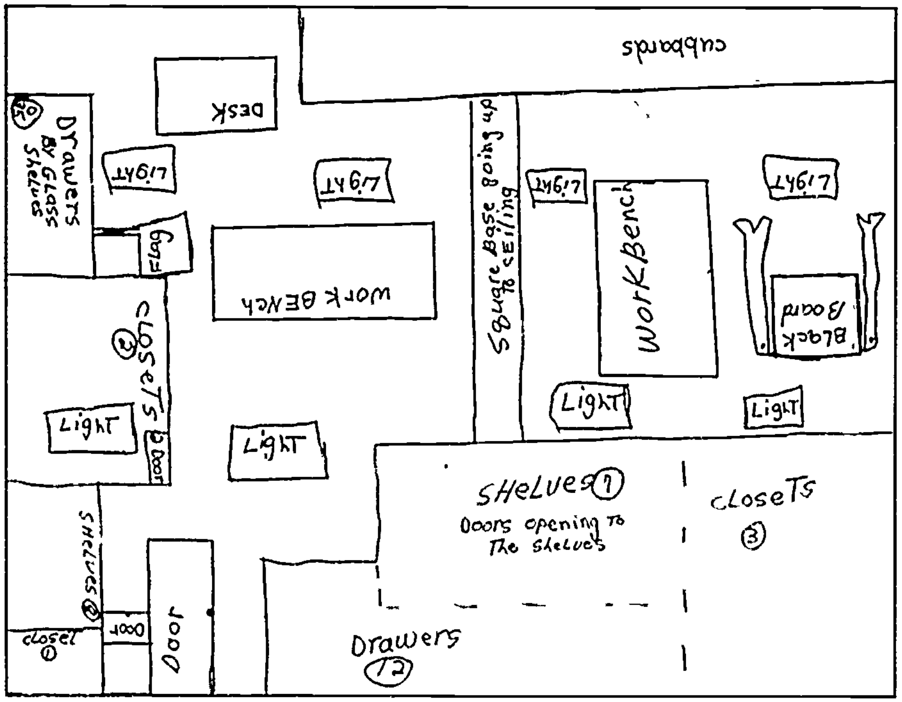
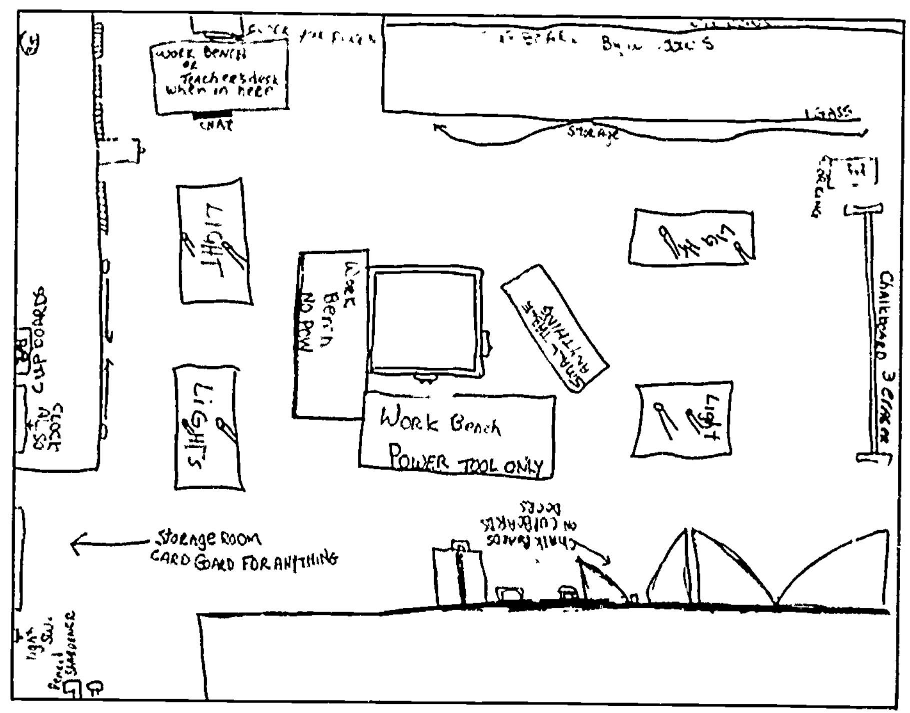


Figure C5-3

Figure C5-4



did a general clean-up, washing cupboards, drawers, and shelves, sweeping the floor, and discarding trash. I also asked the children to draw all the storage areas and to indicate where to store tools and supplies. Figures C5-3 and C5-4 and show some of their drawings.

The following week, we temporarily put the floor plans aside and concentrated on a safety campaign for the Design Lab. We began by making a list of some of the unsafe situations that might occur there.

Unsafe Situations

Using power tools incorrectly
Not wearing safety goggles and safety equipment
No supervision
Using hand tools incorrectly
Unprotected glass
Being careless
Bad behavior
Not following directions
Outlets: overloading circuits, sticking inappropriate objects into, not pulling cord out by head
Cords: too short, wet, possibility of tripping over
Leaving materials lying around
Protecting the tools if door to lab left unlocked
Too many people
Horseplay

To avoid these unsafe conditions, we decided to make rules to post in the lab. We agreed to state the rules positively (see poster example in Figure C5-5).

Use tools correctly.
Wear safety equipment when using power tools.
Have adult supervision at all times.
Be careful.
Follow directions.
Pull out cords by their heads.
Put tools back where they belong.
Clean up after you're done.

While most of the children were making the safety posters, a small group of students, designated the Furniture Group, rearranged the tables, chairs, and movable shelves in the lab. They operated in an extremely organized manner. First they chose a chairman. Then, as a group, they went

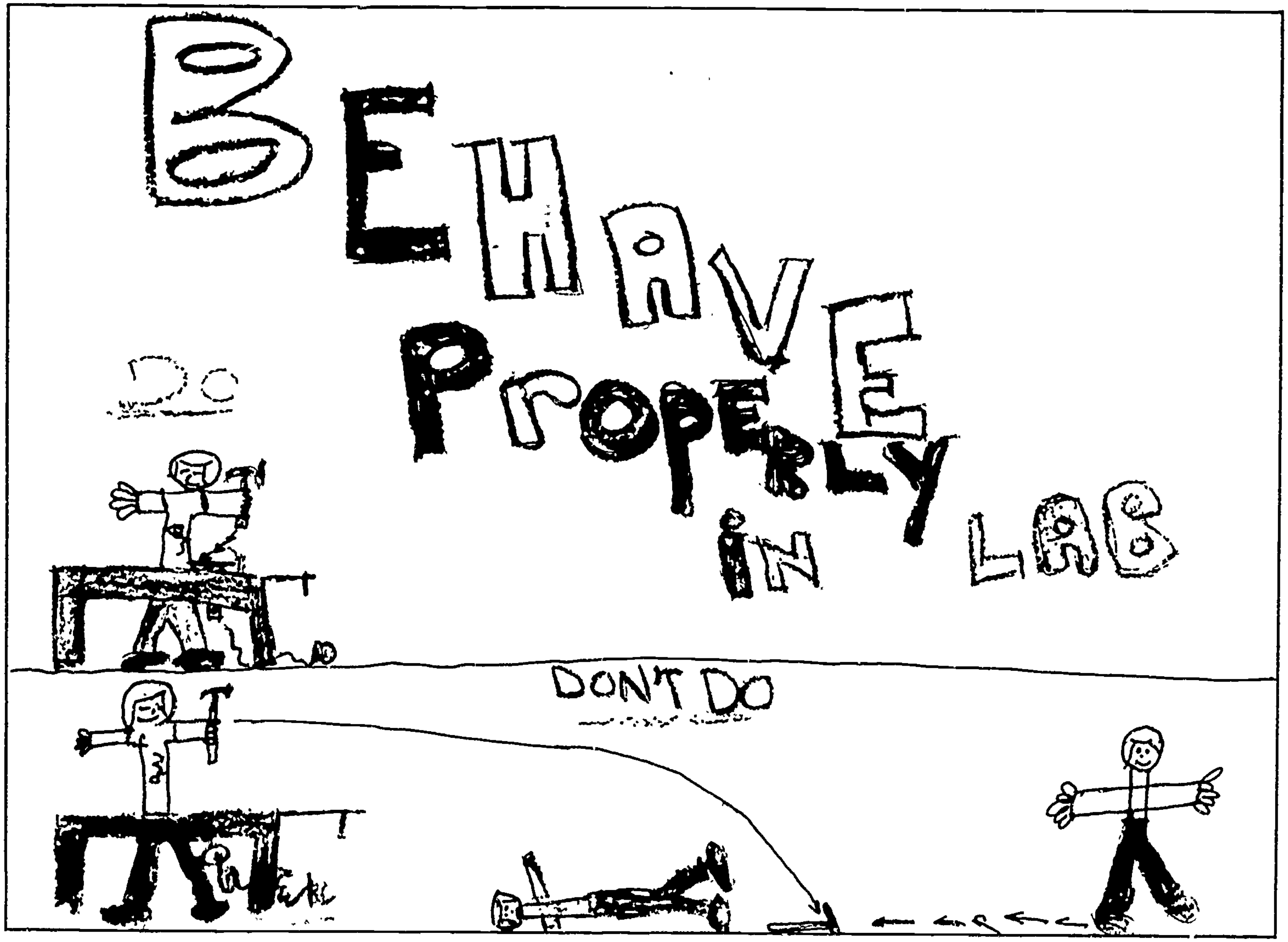


Figure C5-5

1. Marbels 236
2. hammers 6
3. folding Rulers 3
4. plibrs 3
5. saws 1
6. markers 6
7. Hack saws 1
8. Hack saw blads 3
9. nails 175
10. scew drivers 4
11. wire 6
12. leveler 1
13. putty knife 2
14. pins 30
15. ruber 3
16. tapes 2
17. bolds & nuts 95
18. spick 1
19. plane 1
20. drills 2
21. hand saws 3
22. baderies 9
23. pouch 1
24. hand saws 2
25 socket wench 1
26 sodering pen 2

paper clip 1
wench 1
cell lights 4
rosin core solder 6
wood drill 1
alagayter clips 2

Figure C5-6

through each student's floor plan, eliminating all but ten designs. They discussed the advantages and disadvantages of each layout and then voted.

Agreeing to follow the floor plan with the most votes, they divided up the work to be done and got busy arranging the lab according to plan. When they were finished, they reassembled to evaluate the results. Pleased by the arrangements, they changed only the placement of one table so that it would not block an electrical outlet. The group then disbanded.

Three other small groups were also busy. Two boys inventoried the scrounged materials, sorting and cataloging them. Figure C5-6 shows the list that they made.

Several other children took inventory of the new tools. Two girls checked the tools against our order forms and the catalog numbers to make sure that we had received what we had ordered. Using the calculator to add the cost of these items, they made sure that the total bill was correct.

The Design Lab was nearly ready to be opened for school use. We borrowed an electric engraver from the police department and one small group volunteered to mark the tools. Another group marked the tools again with a black permanent felt-tip marker. As each tool was marked, it was put away in one of two cupboards:

Cupboard #1

Measuring Tools	
Saws Lathes	Planes Wrenches Pliers
Screw-drivers	Hammers

Cupboard #2

Drill bits	Knives Files
Electric wire	C-Clamps

Two students painted a 4' x 8' piece of pegboard which was then hung on the wall, and the most frequently used tools were placed on it. The rest of the students finished their safety posters and hung them around the Design Lab.

By mid-October, another class asked us whether the Design Lab would be open by October 21. The students thought that they would be finished by then and said yes. This brought up the topic of procedures for using the lab. We discussed the following questions:

- Can a whole class use the lab at one time?

- Who will supervise the whole class? Will one teacher be enough?

- Do we need to know in advance who would like to use the lab? How much in advance?

- Should we have a sign-up sheet? If so, where should it be posted? What information should be on it?

After much discussion, we decided on several procedures. An entire class could use the lab we agreed, if a teacher were making a demonstration. If students were working on individual projects, however, there would have to be more than one adult present. The maximum number of students allowed in the Design Lab at one time would be limited to one person per work space, with perhaps four to six people at a table. A sign-up sheet would be located in our room and would contain the following information:

Time in ________ Teacher's name ________________

Time out _______ Number of students ____________

Purpose for using the lab ___________________________

Will adult supervision be provided? _________________

We settled on a one-week notice for using the lab so that I could secure additional adult supervision, if necessary.

Approximately seven weeks after we had first started planning for it, the Design Lab was opened for school use. Other classes immediately began using the lab during their work on other USMES units. Heavy use of the Design Lab continued throughout the year.

D. References

1. LIST OF "HOW TO" CARDS

Below are listed the current "How To" Card titles that students working on the Design Lab 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.

ELECTRICITY

EC 1 How to Make Simple Electric Circuits
EC 2 How to Check a Circuit by Tracing the Path of the Electricity
EC 3 How to Make Good Electrical Connections
EC 4 How to Find Out What Things to Use in an Electric Circuit
EC 5 How to Make a Battery Holder and Bulb Socket
EC 6 How to Make a Battery and Bulb Tester
EC 7 How to Find Out Why a Circuit Does Not Work
EC 8 How to Turn Things in Electric Circuits On and Off
EC 9 How to Find Out Why a Bulb Sometimes Gets Dim or Goes Out When Another Battery Is Added to the Circuit
EC 10 How to Connect Several Things to One Source of Electricity
EC 11 How to Draw Simple Pictures of Electric Circuits

GEOMETRY

G 3 How to Construct a Circle Which Is a Certain Distance Around

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 2 How to Measure Distances
M 3 How to Measure Large Distances by Using a Trundle Wheel
M 9 How to Make a Conversion Graph to Use in Changing Measurements from One Unit to Another Unit

MEASUREMENT (cont.)	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

New titles to be added:

How to Round Off Data
How to Design and Analyze a Survey
How to Choose a Sample
How to Design an Experiment
How to Make and Use a Cumulative Distribution Graph
How to Measure Light Intensity
How to Measure Sound Intensity

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. This additional set should be available in 1977.

*Presently called Slope Diagram.

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 Design Lab 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 13 People and Space by Gorman Gilbert

ELECTRICITY

EC 1 Basic Electric Circuits (based on suggestions by Thacher Robinson)

EC 2 Trouble Shooting on Electric Circuits (based on suggestions by Thacher Robinson)

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

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

MEASUREMENT

M 1 Gulliver's Travels Activity by Abraham Flexer

M 3 Determining the Best Instrument to Use for a Certain Measurement by USMES Staff

PROBABILITY AND STATISTICS

PS 1 Collecting Data in Sets or Samples by USMES Staff

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
R 3 *Making and Using a Scale Drawing* by Earle Lomon

SIMULATION ACTIVITIES

SA 2 *Set Theory Activities: Rope Circles and Venn Diagrams* by Merrill Goldberg

3. BIBLIOGRAPHY OF NON-USMES MATERIALS

The following materials are references that may be of some use during work on Design Lab 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*.

Books for Teachers

Biological Sciences Curriculum Study (BSCS). *Investigating Your Environment*--Student Handbook.
Section on noise and noise measurement may be useful for teachers and older students.

Blackwell, F.F., Nuffield Junior Science, *Apparatus, A Source Book of Information and Ideas.* London: William Collins, Sons & Co., Ltd., 1967. (Distributed by Agathon Press, Inc., 150 Fifth Avenue, N.Y., N.Y. 10011.)
Sections on elementary electricity, light, sound and heat may help teachers whose students are building burglar alarms or investigating physical improvements in the lab.

Brandwein, Paul F., et al. *Concepts in Science.* Teacher's Guide Number 4. Chicago, Illinois: Harcourt Brace Jovanovich, Inc., 1975.
First unit, "The Bounce of Sound," has description of sound concepts and ideas on soundproofing.

Early Childhood Education Study. *Building with Tubes* and *Building with Cardboard.* Newton, Massachusetts: Education Development Center, 1970.
Both pamphlets contain helpful hints for working with cardboard materials and ideas for building stools, chairs, tables, shelves, and storage containers.

Farallones Designs. *Farralones Scrapbook*. Berkeley: The Boys in the Back, 1971. (Order from Farallones Designs, Star Route, Point Reyes Station, California 94956.)
Two chapters are particularly useful: "Ways to Change Classrooms" and "Trash Can Do It."

Reader's Digest. *Complete Do-It-Yourself Manual*. Pleasantville, New York: Reader's Digest, 1973.
A good book for anyone who wants to find out more about how to select and use tools.

Workshop for Learning Things. *Further Advantures of Cardboard Carpentry*. Watertown, Massachusetts: Workshop for Learning Things (5 Bridge Street, 02172), 1972. ($3.50).
Contains drawings and photographs of plans and building techniques for making Tri-Wall furniture.

Books for Children

Beim, Jerrold. *Tim and the Tool Chest*. New York: William Morrow & Co., 1951.
Young Tim learns from his father the proper way to use tools and then gets his own tool chest. Illustrates how to use tools properly. For grades 1-6.

Sources of Design Lab Supplies

Brookstone Company, 15 Brookstone Building, Peterborough, New Hampshire 03458.
Free catalog, *Hard-to-Find Tools and Other Fine Things*, has some tools (e.g., handsaw sharpener and strudy handsaw) that might make good additions to the Design Lab inventory.

Sears, Roebuck, and Company.
Source for Craftsman tools, which carry a lifetime guarantee. If a tool breaks, it will be replaced free of charge, no questions asked.

Workshop fo Learning Things, 5 Bridge Street, Watertown, Massachusetts 02172.
Our Catalog ($1.00) contains several tools useful for working with Tri-Wall (e.g., slot cutting saws and markers, circle cutters, strip cutters).

For sources of Tri-Wall, see USMES *Design Lab Manual*.

175

4. GLOSSARY

The following definitions may be helpful to a teacher whose class is investigating a Design Lab 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.

Calibration — The setting and marking of an instrument to correspond to standard measurements.

Circuit — A path through which electricity can flow if the path is continuous.

- *Closed Circuit* — A circuit that provides a continuous path for electricity.
- *Open Circuit* — A circuit that does not provide a continuous path for electricity.
- *Parallel Circuits* — A circuit in which two or more electrical components (such as bulbs and buzzers) are connected so that the electricity divides into two or more paths.
- *Series Circuit* — A circuit in which the electricity flows through all components along a single path.
- *Short Circuit* — A low resistance path resulting in too much current that may damage those components in the path.

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

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.

Current — The flow of electric charge. Technically, the rate of flow of electric charge through a conductor: how much electric charge passes through a given point in a circuit in a given amount of time. Measured in amperes (amps).

Alternating Current (AC) — Electric current that flows first in one direction and then in the opposite direction in regular cycles. Most household current is AC.

Direct Current (DC) — Electric current that flows only in one direction. Current from batteries is DC.

Data — Any facts, quantitative information, or statistics.

Decibel — A unit of measurement of sound intensity. The number of decibels is equal to ten times the logarithm of the ratio of the sound intensity and a standard reference point. The reference point is the power required to produce a barely audible sound at the frequency of 1000 Hertz (i.e., a pitch nearly two octaves above middle C).

Degree — A unit of measurement of temperature or angle.

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

Electromagnet — A coil of wire, usually wound on an iron core, which produces a strong magnetic field when current goes through it.

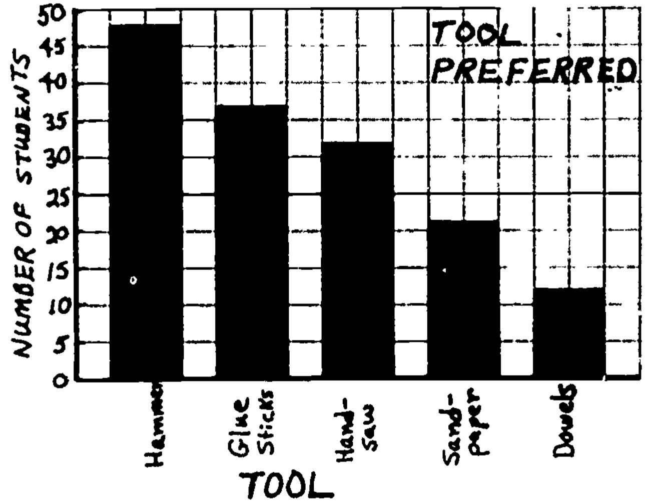
Frequency — The number of times a certain event occurs in a given unit of time or in a given total number of events.

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: number of students preferring different tools to add to the Design Lab inventory. (See next page.)

Bar Graph (cont.)

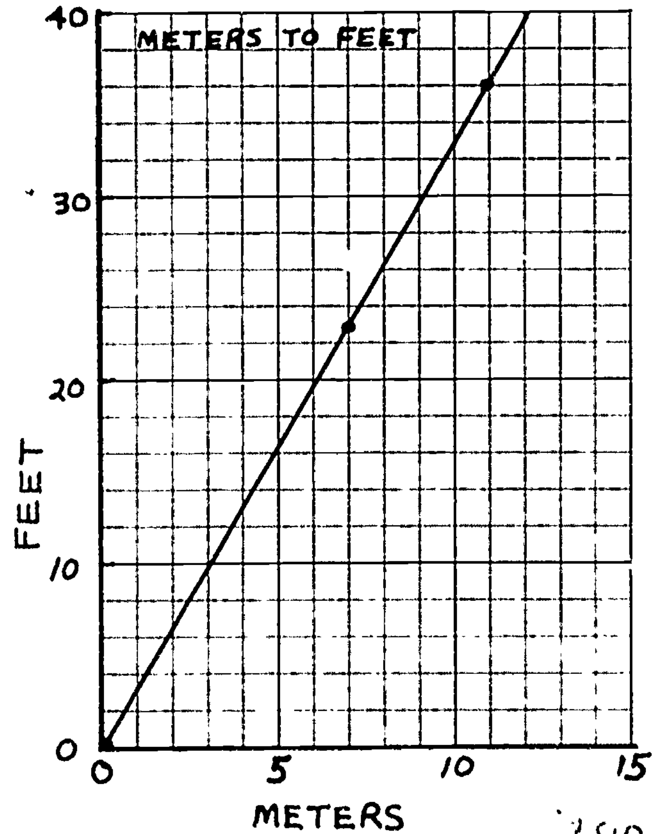
TOOL	NUMBER OF STUDENTS
Hammer	48
Glue sticks	37
Handsaw	32
Sandpaper	21
Dowels	12



Conversion Graph

A line graph that is used to change one unit of measurement to another. For example, changing meters to feet or vice versa.

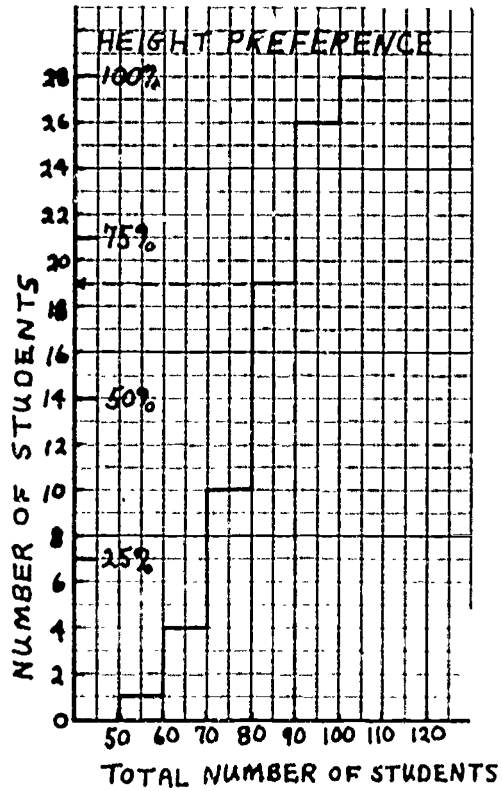
METERS	FEET
0	0
7	23.0
11	36.1



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 students who expressed some preference for table height). 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 19 students, or about 70 per cent, prefer a table height of 90 centimeters or less.

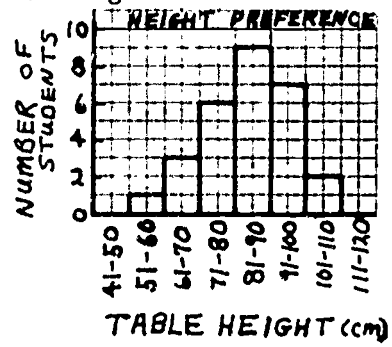
HEIGHT (cm)	TOTAL NUMBER OF STUDENTS
50 or less	0
60 " "	1
70 " "	4
80 " "	10
90 " "	19
100 " "	26
110 " "	28



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: number of students who prefer given table heights.

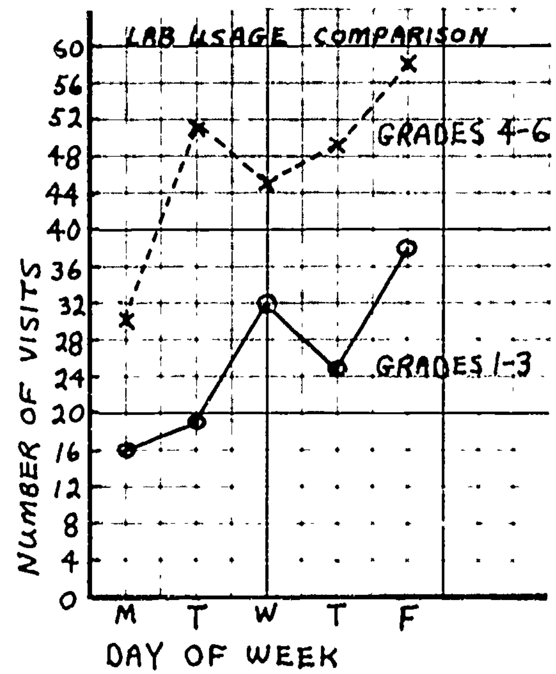
HEIGHT (cm)	NUMBER OF STUDENTS
41-50	0
51-60	1
61-70	3
71-80	6
81-90	9
91-100	7
101-110	2



Line Chart

A bar graph that is represented by circles, triangles, or crosses 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: number of lab visits per day for two sets of students.

DAY	NUMBER OF VISITS Grades 1-3	Grades 4-6
M	16	30
Tu	19	51
W	32	45
Th	25	49
F	38	58



Line Graph

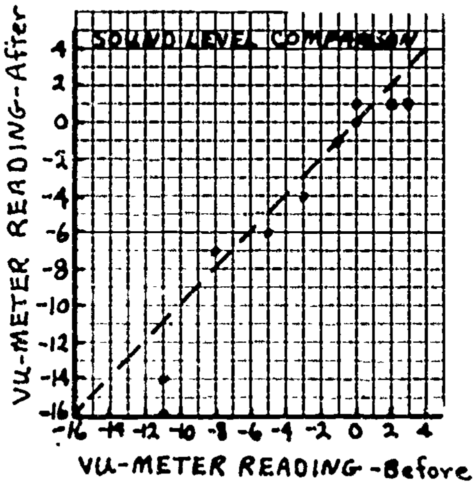
A graph in which a smooth line or line segments pass through or near points representing members of a set of data. Since the line represents an infinity of points, the variable on the horizontal axis must be continuous. If the spaces between the markings on the horizontal axis have no meaning, then the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

Q-Q Graph

A graph that shows the comparison between the same type of data collected from two groups of people or from two different situations. Example: sound-level readings (taken with a VU-meter on a tape recorder) before and after soundproofing the Design Lab. The data for each set is ordered and the smallest measurement of one set plotted against the smallest of the other set, the second smallest against the second smallest, etc. The scatter of points is compared to a reference line, a dashed 45° line that represents data from two identical sets.

VU-METER READINGS

Before Soundproofing	After Soundproofing
-11	-16
-11	-14
-8	-7
-5	-6
-3	-4
-1	-1
0	0
0	+1
+2	+1
+3	+1

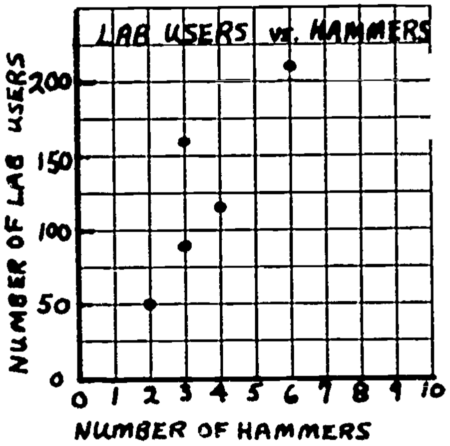


Scatter Graph

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 number of lab users in a school vs. the number of hammers in the school's Design Lab.

Scatter Graph (cont.)

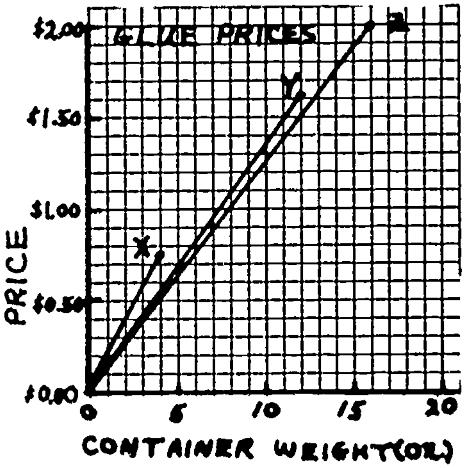
NUMBER OF HAMMERS	NUMBER OF STUDENTS
2	50
3	82
3	160
4	115
6	212



*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 the slopes of several lines, different ratios can be compared; the less steep the line, the smaller the ratio. For example, in the diagram showing the ratio of price to weight for different brands of glue, the ratio of price to weight for Brand Z is less than that for Brand X or Y, and therefore, Brand Z costs the least per ounce.

BRAND	PRICE	WEIGHT
X	$0.75	4 oz.
Y	$1.62	12 oz.
Z	$2.00	16 oz.



Histogram

See *Graph*.

Hypothesis

A tentative conclusion made in order to test its implications or consequences.

*Formerly called Triangle Diagram.

Inference — A conclusion derived from facts or information considered to be valid and accurate.

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.

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 per cent = 72/100 = 0.72, where the symbol % represents 1/100.

Percentage — A part of a whole expressed in hundredths.

Population — Any group of objects (e.g., people, tools, 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.

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 can use a workbench at the same time to the area of the workbench top might be 6 children/4½ square meters or 6 children:4½ square meters.
Recycle	To process a discarded item for reuse, either for its original purpose or for a new purpose.
Resistance	The opposition that a device or material offers to the flow of electricity, measured in ohms.
Retail Price	The price of goods sold in small quantity to the consumer.
Sample	A representative fraction of a pupulation 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 of a drawing of a lab and the actual lab).
Scale Drawing	A drawing whose dimensions are in direct proportion to the object drawn.
Scale Model	A three-dimensional representation constructed to scale.
Set	A collection of characteristics, persons, or objects. Each thing in a set is called a member or an element.
Set Theory	The branch of mathematics that deals with the nature and relations of sets.
Slope Diagram	See *Graph*.
Sound Intensity	The level or loudness of a sound. A measure of how much sound energy flows through a given area in a given time. Measured in decibels or watts/cm^2.
Sound Level Meter	An instrument used to measure sound intensity.

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

Switch — A device for opening and closing a circuit.

Tally — A visible record used to keep a count of some set of data, expecially a record of the number of times one or more events occur. Example: a record of the number of students who use the Design Lab during a particular week.

Temperature — A measure of hotness or coldness. Technically, an indication of the average kinetic energy of molecules. Temperature is commonly measured in degrees Fahrenheit or degrees centigrade (Celsius).

Thermometer, Centigrade (or Celsius) — A thermometer on which the interval between the normal freezing and boiling points of water is divided into 100 parts or degrees, ranging from $0^{o}C$ to $100^{o}C$.

Thermometer, Fahrenheit — A thermometer on which the interval between the normal freezing and boiling points of water is divided into 180 parts or degrees, ranging from $32^{o}F$. to $212^{o}F$.

Voltage — A measure of the electrical energy per unit charge in a circuit. For a given circuit, as the voltage increases, the current increases.

Watt — A unit of measurement of power (energy per unit of time or work per unit of time). Although light bulbs are rated in watts, the wattage indicates both heat and light output.

Wire Gauge — AWG (American Wire Gauge)--a system for numbering wire sizes; the larger the AWG number, the smaller the diameter of wire.

E. Skills, Processes, and Areas of Study Utilized in Design Lab 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 Design Lab 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 Design Lab 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 Design Lab Design and knowing the extent that they will be used, teachers can postpone the teaching 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 Design Lab 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 Design Lab 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 po ible 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

MATHEMATICS	Overall Rating
Basic Skills	
Classifying/Categorizing	2
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	2
Estimating/Approximating/Rounding Off	1
Organizing Data	1
Statistical Analysis	2
Opinion Surveys/Sampling Techniques	2
Graphing	2
Spatial Visualization/Geometry	1
Areas of Study	
Numeration Systems	1
Number Systems and Properties	1
Denominate Numbers/Dimensions	1
Scaling	1
Symmetry/Similarity/Congruence	2
Accuracy/Measurement Error/ Estimation/Approximation	1
Statistics/Random Processes/Probability	2
Graphing/Functions	2
Fraction/Ratio	1
Maximum and Minimum Values	3
Equivalence/Inequality/Equations	2
Money/Finance	1
Set Theory	3

SCIENCE	Overall Rating
Processes	
Observing/Describing	1
Classifying	2
Identifying Variables	2
Defining Variables Operationally	2
Manipulating, Controlling Variables/ Experimenting	2
Designing and Constructing Measuring Devices and Equipment	2
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	1
Mechanical Work and Energy	1
Solids, Liquids, and Gases	2
Electricity	3
Heat	-
Light	1
Sound	1
Animal and Plant Classification	-
Ecology/Environment	-
Nutrition/Growth	-
Genetics/Heredity/Propagation	-
Animal and Plant Behavior	-
Anatomy/Physiology	3

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	1
Collecting, Recording Data/Measuring	2
Organizing, Processing Data	2
Analyzing, Interpreting Data	2
Communicating, Displaying Data	2
Generalizing/Applying Process to Daily Life	1
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	3
Political Science/Government Systems	3
Recent Local History	3
Social Psychology/Individual and Group Behavior	3
ciology/Social Systems	3

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

REAL PROBLEM SOLVING IN DESIGN LAB DESIGN

Identifying and Defining Problems	• Students decide that furniture arrangement is a problem in the Design Lab. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables.*
Deciding on Information Needed	• Students decide to conduct an opinion survey to find whether the present lab arrangement causes difficulty for other students. • After a discussion students decide that they need to collect data on room and furniture dimensions. • After analyzing data, students decide that they need more data on the amount of space required for various lab activities. • Students decide that they need to have more information about fire regulations and fire drill procedure. • Students decide to conduct another opinion survey after they have rearranged the furniture to find out whether students feel that the new lab arrangement is better.
Determining What Needs to Be Done First, Setting Priorities	• Students decide to observe the traffic flow in the lab, to find out if additional tables or workbenches are needed. • Students decide to make a scale drawing of the lab and the furniture before actually moving furniture. • Students decide to find out about fire regulations before making a final plan to rearrange the furniture. • Students decide to ask the principal and the Design Lab manager for permission to implement their changes in the Design Lab.
Deciding on Best Ways to Obtain Information Needed	• Students decide to measure a random sample of students from each grade to find the best height for a workbench. • Students telephone lumberyards to find the cost of materials for workbench. • Students decide to ask fire department officials about fire regulations at the school. • Students decide to test each other to see how much space is required for sawing, hammering, and other Design Lab activities.

Working Cooperatively in Groups on Tasks	• Students form groups to observe the traffic flow in the lab, to measure the lab and furniture and make a scale layout, to measure waist-to-floor heights of other students, to obtain information on fire regulations, and to conduct surveys.
Making Decisions as Needed	• Students decide to work in groups so that more can be accomplished. • Students decide that a rectangular workbench provides more working space than a round table. • Students decide that a particular layout allows for more space and provides easy exiting in case of fire.
Utilizing and Appreciating Basic Skills and Processes	• Students measure the lab room and furniture to draw a scale layout. • Students divide to find a scale for scale layout. • Students draw graphs of waist-to-floor heights of a sample of students. • Students write letters to fire department officials and to safety organizations. • Students recognize that improving the Design Lab will help many people besides themselves. • Students give oral presentations to principal. • Students telephone local lumberyards to obtain information. • 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 surveys to find out whether the lab arrangement is a problem for others and whether a new lab arrangement is better than the old one. • Students count the number of students working in each part of the lab. • Students measure the lab room and furniture. • Students measure waist-to-floor heights of a sample of students. • Students measure how much space is needed for different Design Lab activities. • Students construct a workbench for the Design Lab. • 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.*

Carrying Out Data Collection Procedures--Opinion Surveying, Researching, Measuring, Classifying, Experimenting, Constructing (cont.)

- See also SOCIAL SCIENCE list: *Observing/Describing; Classifying; Manipulating, Controlling Variables/ Experimenting; Collecting; Recording Data/Measuring.*

Asking Questions, Inferring

- Students ask whether the lab layout hinders their work and they infer from observations that it does.
- Students ask whether another workbench is needed. They infer from their data it will help to reduce overcrowding.
- Students ask whether there is enough space near the door in the lab. They infer from their scale drawing that the space is big enough.
- Students ask whether the new furniture arrangement has improved the lab. They infer from their observations and survey data that it has.
- 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 Sources

- Students recognize the qualitative aspects of obtaining data from opinion surveys as distinct from data they gather by actual measurements, such as counting the number of students in each work area.
- Students constructing a workbench find that student height is irrelevant but that the waist-to-floor height is necessary.
- Students recognize that merchants are reliable sources for information on prices of materials, that fire department officials are reliable sources for information on fire regulations.

Evaluating Procedures Used for Data Collection and Analysis, Detecting Flaws in Process or Errors in Data

- Students measure the lab room and furniture with a variety of measuring devices and obtain varying results. They discuss the discrepancies and choose one instrument and one procedure for making final measurements.
- Students decide that their opinion surveys need improvement and then discuss changes they need to make.
- Students discuss the manner in which they measured waist-to-floor heights of a sample of students and then refine their procedure.
- See also MATHEMATICS list: *Estimating/Approximating/ Rounding Off.*

Organizing and Processing Data	• Students record their data on charts. • Students try out different furniture arrangements on their scale model. • Students order and group measurements of waist-to-floor heights to draw histograms. • See also MATHEMATICS list: *Organizing Data*. • See also SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data*.
Analyzing and Interpreting Data	• Students find the median and range of waist-to-floor measurements of other students. • Students determine from their graphs which lumberyard gives them the best buy. • See also MATHEMATICS list: *Comparing; Statistical Analysis; Opinion Surveys/Sampling Techniques; Graphing; Maximum and Minimum Values*. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.
Predicting, Formulating Hypotheses, Suggesting Possible Solutions Based on Data Collected	• After counting the number of students working in each part of the lab and surveying students, children recommend that another workbench be constructed. • After investigating, students suggest that a particular lab layout will reduce overcrowding and meet fire regulations. • 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 discuss advantages and disadvantages of proposed lab arrangements. • Students constructing workbench investigate cost, estimate use and effect.
Trying Out Various Solutions and Evaluating the Results, Testing Hypotheses	• Students use a scale layout of the lab to find the best arrangement. • Students conduct a survey to find out how others feel about the new arrangement of the lab and whether they feel it is efficient. • After constructing a workbench, students survey lab users to find out whether the height is comfortable for most people.

Trying Out Various Solutions and Evaluating the Results, Testing Hypotheses (cont.)

- 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 a scale layout of the Design Lab.
- Students make a histogram to show variations in the waist-to-floor heights of their sample of students.
- Students make a traffic flow diagram to show exiting from the Design Lab during fire drills.
- See also MATHEMATICS list: *Graphing, Scaling.*
- See also SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data.*
- See also LANGUAGE ARTS list.

Working to Implement Solution(s) Chosen by the Class

- Students make a presentation of rearrangement plans to the principal and the Design Lab manager.
- Students rearrange the Design Lab according to their chosen layout.
- Students design and construct a needed workbench.

Making Generalizations That Might Hold True Under Similar Circumstances; Applying Real-Problem Solving Process to Other Real Problems

- Students who have drawn graphs to display data in one instance more readily draw graphs in other instances.
- Students working on Design Lab Design apply skills they have acquired to their work on Classroom Design.
- See also SCIENCE list: *Generalizing/Applying Process to New Problems.*
- See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

ACTIVITIES IN DESIGN LAB DESIGN UTILIZING MATHEMATICS

Basic Skills

Classifying/Categorizing

- Categorizing characteristics or properties of construction materials.
- Categorizing characteristics of construction materials in more than one way.
- Organizing and classifying sets of tools, construction materials, activities, or information.
- Distinguishing sets and subsets of quantitative survey data on preferred tool sizes, such as upper grade and lower grade preferences.
- Using the concepts of sets for arranging a layout according to Design Lab activities by placing similar activities together (e.g., all power tools near outlets).
- See also SCIENCE list: *Classifying.*
- See also SOCIAL SCIENCE list: *Observing/Describing/ Classifying.*

Counting

- Counting votes to decide which Design Lab problem to work on.
- Counting survey data or questionnaire data on preferences for additional tools and materials.
- Counting number of seconds to exit from Design Lab during a fire drill, counting number of lab users per week.
- Counting lab tools and supplies to make an inventory list.
- Counting amount of money earned at an event to raise money for more lab tools and supplies.
- Counting to read scales on meter sticks, rulers, or sound meters.
- Counting by sets to find a scale for graph axes.

Computation Using Operations: Addition/Subtraction

- Adding one-, two-, or three-digit whole numbers to find the total tally of survey votes or the total measurement of table area needed to accommodate a given number of students.
- Adding minutes and seconds when timing how long it takes to find particular tools.
- Subtracting distance measurements to see how much space remains when a supply cabinet is placed against one wall of the lab.
- Subtracting to find the difference between predicted and actual dimensions of the lab.

Computation Using Operations: Addition/Subtraction (cont.)

- Subtracting one-, two-, or three-digit whole numbers to find ranges for graph axes.
- Subtracting medians to compare sets of data.

Computation Using Operations: Multiplication/Division

- Using multiplication and division to increase or decrease measurements for scale drawings or scale models.
- Multiplying whole numbers to find the total measurement of posterboard needed to make safety posters.
- Multiplying or dividing to find scale for graph axes.
- Dividing to find a unit measure or unit cost.
- Multiplying and dividing to convert from inches to feet.
- Dividing to calculate the average number of lab users per day, per week.
- Dividing to calculate ratios, fractions, or percentages.

Computation Using Operations: Fractions, Ratios, Percentages

- Using mixed numbers to perform calculations, such as determining measurements for shelf or table.
- Changing fractions to higher or lower terms (equivalent fractions) to perform operations such as calculating dimensions of furniture.
- Using ratios and fractions to convert from one unit of measure to another.
- Using ratios to increase or decrease measurements for a scale drawing of the lab.
- Using fractions in measurement, graphing, graphic comparisons, or scale drawings.
- Calculating actual measurements from scale drawings using the scale of the scale drawing.
- Calculating percentage of students who prefer a particular tool size, percentage of lab users in the total school population.

Computation Using Operations: Business and Consumer Mathematics/ Money and Finance

- Adding, subtracting, multiplying and dividing dollars and cents to analyze costs of adding new tools and supplies to the Design Lab inventory, costs of constructing a mobile tool carrier.
- Gaining experience with finance, sources, uses, and limitations of revenues for purchasing new Design Lab materials.
- Investigating costs of Design Lab materials vs. use of materials and budget restrictions.
- Using comparative shopping when purchasing materials.
- Assessing costs, benefits of inventory and record keeping, quantity purchasing, and trade-offs between quality and cost.

Measuring

- Using arbitrary units (e.g., children's feet) to measure dimensions of the Design Lab.
- Using different standard units of measure to measure lab furniture.
- Measuring waist-to-floor height of a sample of students to determine workbench height.
- Using different measuring tools to measure length.
- Reading measuring devices accurately.
- Timing the length of lab sessions with a clock or wristwatch.
- Converting from meters to centimeters.
- See also SCIENCE list: *Measuring/Collecting, Recording Data.*
- See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring.*

Comparing

- Using the concepts of *greater than* and *less than* in making comparisons of the space required for different lab activities.
- Comparing measurements obtained from a meter stick and a tape measure.
- Comparing estimated and actual number of lab users per week, per month.
- Making graphic comparisons of fractions and ratios on body proportions to determine workbench height.
- See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data.*

Estimating/Approximating/Rounding Off

- Estimating the number of people who will use a mobile Design Lab cart.
- Estimating sizes of worktables, measurements of the lab room, amount of space needed for a lab activity, cost of purchasing new tools.
- Estimating the placement of safety posters on walls at heights determined by eyeballing.
- Determining when a measurement of sound is likely to be accurate enough for a particular purpose.
- Using approximation in constructing storage shelves.
- Rounding off measurements while measuring furniture sizes.
- Rounding off data after measuring lab room dimensions.

Organizing Data

- Recording data on charts.
- Tallying on bar graphs, histograms.
- Ordering real numbers on a number line or graph axis.

Organizing Data (cont.)	• Ordering measurement results on preferred workbench heights. • Ordering centimeters, meters and inches, feet, yards. • See also SCIENCE and SOCIAL SCIENCE lists: *Organizing, Processing Data*.
Statistical Analysis	• Finding the median and range in an ordered set of data on preferences for workbench height, or waist-to-floor measurements of a sample of students. • Taking repeated measurements of room length and width and using the median measurements. • Finding and comparing medians and modes of data on sound levels. • Finding the mean (average) of the amount of Tri-Wall or wood used (per month) to determine how much is needed for the rest of the year. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.
Opinion Surveys/Sampling Techniques	• Conducting surveys; defining data collection methods and the makeup and size of the sample. • Evaluating survey methodology, data obtained, size and type of samples. • Using a sample of students (waist-to-floor heights) to determine the height for a workbench. • See also SCIENCE and SOCIAL SCIENCE lists: *Analyzing, Interpreting Data*.

Graphing	• Using alternative methods of displaying data, e.g., charts, graphs.
	• Making a graph form--dividing axes into parts and deciding on an appropriate scale.
	• Representing data on graphs.
	  • Bar graph--number of students preferring different Design Lab problems be solved.
	  • Conversion graph--changing meters to feet and vice versa for buying lumber.
	  • Cumulative distribution graph--workbench height preferences of students.
	  • Histogram--number of students preferring different workbench heights.
	  • Line chart--number of lab visits per day for upper and lower grades.
	  • Q-Q graph--noise levels before and after installing sound-absorbing materials.

Graphing (cont.)

  - Scatter graph--number of lab users in a school vs. number of hammers in that school's Design Lab.
  - Slope diagram--cost vs. quantity comparisons.
- Using three-dimensional graphical representations.
- Obtaining information from graphs.
- Representing several sets of data on one graph.
- See also SCIENCE and SOCIAL SCIENCE lists: *Communicating, Displaying Data*.

Spatial Visualization/Geometry

- Drawing or constructing a design or model of a mobile tool carrier.
- Using geometric figures to understand and utilize relationships, such as area-to-perimeter for different shapes of table tops.
- Using standard mensurational formulas, e.g., A = L x W.
- Measuring and constructing scale layouts using rulers, compasses, and protractors.
- Using spatial arrangements to convey information on possible layouts for the lab room.
- Making a flow diagram to show exiting from lab during a fire drill.

Areas of Study

Numeration Systems

- Using the decimal (metric) system in measuring room dimensions for a scale drawing.
- Using fractions in measuring the dimensions of a mobile tool carrier.
- Using the decimal system in calculating costs of lab materials and tools.

Number Systems and Properties

- See *Computation Using Operations*.

Denominate Numbers/Dimensions

- See *Measuring*.

Scaling

- Deriving information from scale drawings of the Design Lab room or of a mobile Design Lab.
- Finding an appropriate scale (proportion) for the scale drawing or scale model.
- Making a scale drawing of the lab room or of a tool cart.

Symmetry/Similarity/Congruence	• See *Spatial Visualization/Geometry.*
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	• Minimizing space and cost in recommending and designing lab equipment or furniture. • Maximizing the use of lab equipment or furniture. • Determining a practical shape for a workbench which yields maximum perimeter/area ratio (to minimize material usage).
Equivalence/Inequality/Equations	• See *Comparing* and *Computation Using Operations.*
Money/Finance	• See *Computation Using Operations: Business and Consumer Mathematics/Money and Finance.*
Set Theory	• See *Classifying/Categorizing.*

ACTIVITIES IN DESIGN LAB DESIGN UTILIZING SCIENCE

Process

Observing/Describing	• Observing that certain parts of the Design Lab are overcrowded. • Observing that noise from the Design Lab can be heard in an adjacent room. • Describing the various noises in the lab that cause distraction. • Observing and describing the differences in Design Lab materials (e.g., lumber, Tri-Wall, posterboard). • Observing that tools come in different sizes. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.
Classifying	• Determining which parts of the lab room are well lighted and which are dark. • Classifying tools according to different characteristics (e.g., electrical vs. hand tool, noisy vs. quiet). • Classifying tools according to size. • Classifying types of activities that are carried cut in the Design Lab. • See also MATHEMATICS list: *Classifying/Categorizing*. • See also SOCIAL SCIENCE list: *Observing/Describing/Classifying*.
Identifying Variables	• Identifying noises, number of lab users, number of tools, and lab layout as variables that could be changed to reduce overcrowding. • Identifying time and location of sound-measuring device as things to be controlled when measuring noise. • See also SOCIAL SCIENCE list: *Identifying Problems, Variables*.
Defining Variables Operationally	• Defining noise level as the VU-meter reading on a tape recorder when the volume is set at five. • Defining number of lab users as the average number of visits per week or per month that people have made to the lab. • Defining the number of students who can work in certain parts of the lab without overcrowding by trial-and-error.

Defining Variables Operationally (cont.)	• Defining a good lab layout as one that meets fire regulations, has sufficient working space, and provides easy access to tools and materials.
Manipulating, Controlling Variables/ Experimenting	• Keeping the volume and the placement of the tape recorder the same each time the noise level is measured. • Measuring the level of noise in the lab under different conditions (e.g., when there are many and when there are few lab users, when different tools are being used.) • Designing and conducting experiments to compare sound-absorbing ability of different materials. • Experimenting to find out what sizes of tools are best for different ages of students. • Designing lab arrangements that meet fire regulations, provide adequate working space and easy access to supplies. • Experimenting to find the number of students who can work comfortably at a table or in a given area at the same time. • See also SOCIAL SCIENCE list: *Manipulating, Controlling Variables/Experimenting*.
Designing and Constructing Measuring Devices and Equipment	• Constructing a worktable or a workbench for use in the lab.
Inferring/Predicting/Formulating, Testing Hypotheses/Modeling	• Predicting that noise levels will be reduced if sound-absorbing materials are used. • Predicting that a different lab layout and another workbench will help reduce overcrowding. • Predicting the number of lab users per week or per month. • Predicting that students will make better use of the lab and have fewer problems if they are given an orientation session during their initial visit to the lab. • Inferring from experiment data that primary children can more easily use smaller tools. • Making scale layouts of possible lab arrangements. • See also SOCIAL SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses*.
Measuring/Collecting, Recording Data	• Using a sound-level device to measure noise every five minutes of a lab period and recording the readings on a chart.

Measuring/Collecting, Recording Data (cont.)	• Measuring the lab room and furniture before making a scale layout to determine the best arrangement. • Measuring and recording the length of time the lab is used each day for a week. • Counting the number of students working in each part of the lab during each period for a week. • See also MATHEMATICS list: *Measuring.* • See also SOCIAL SCIENCE list: *Collecting, Recording Data/Measuring.*
Organizing, Processing Data	• Recording data on a chart. • Ordering data on noise levels from smallest to largest. • Tabulating measurements of lab room and furniture before making a scale layout. • See also MATHEMATICS list: *Organizing Data.* • See also SOCIAL SCIENCE list: *Organizing, Processing Data.*
Analyzing, Interpreting Data	• Calculating the mean (average) sound level when different tools are being used. • Calculating maximum and minimum lengths of time lab is used during each period and during the day and week. • Calculating maximum and minimum numbers of students working in each part of the lab. • Determining when the present lab schedule leads to overcrowding and to noise problems. • Determining the amount of lumber needed to construct a new workbench or a mobile tool cart. • Determining the best arrangement of the lab. • 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	• Making a dimensioned sketch of a proposed workbench or tool cart to get approval from the class. • Showing data on various types of graphs. • Showing proposed new layouts on a scale drawing of the lab. • See also MATHEMATICS list: *Graphing.* • See also SOCIAL SCIENCE list: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.

Generalizing/Applying Process to New Problems	• Using knowledge acquired from working on one aspect of the Design Lab to help solve other lab problems. • Applying skills learned from Design Lab Design to work on Classroom Design, Play Area Design, or Eating in School. • See also SOCIAL SCIENCE list: *Generalizing/Applying Process to Daily Life.*

Areas of Study

Measurement	• Reading measuring devices accurately. • Measuring the lab room and furniture using standard and nonstandard units of measure. • Using stopwatches to time how long it takes lab users to exit during a fire drill. • Measuring the amount of space needed for different lab activities such as hammering, sawing. • Measuring sound and light levels with commercial instruments. • Measuring amount of space needed for tools on a mobile Design Lab cart. • See also MATHEMATICS list: *Measuring.*
Force	• Observing that force must be exerted to use a handsaw. • Observing that it takes less force to use lighter tools. • Observing that saber saws are faster and require less effort to operate than handsaws when cutting Tri-Wall or lumber. • Observing that force must be exerted to hammer nails into wood.
Friction	• Observing that a blade becomes warmer when a piece of Tri-Wall or wood is sawed vigorously because doing work against the force of friction generates heat. • Observing that rolling friction is less than sliding friction when measuring the levelness of a table. • Observing that a smooth surface offers less resistance to the motion of sandpaper.
Mechanical Work and Energy	• Observing that using handsaws, hammers, and other tools requires energy. • Observing that electrical energy is transformed into mechanical energy when power tools are used. • See also *Force.*

Solids, Liquids, and Gases

States of Matter	• Observing that glue is available in liquid or solid form, each with different properties. • Observing that a solid stick of glue is turned into a hot liquid glue by using a glue gun.
Properties of Matter	• Observing that different construction materials, such as lumber and Tri-Wall, have different properties that make them useful for different purposes. • Observing that paper materials available for making posters have different colors and different weights. • Observing, while mixing tempera paints or dyes, that the dry powder mixes uniformly with water. • Observing the effects of physical or chemical wear on materials. • Observing that glue, lumber, paper, paint, and other materials have particular odors.
Electricity	• Observing that electricity can light bulbs and that electrical energy can be transformed into light energy. • Observing that electricity does not flow through the insulation on a wire. • Observing that the light goes on when the switch is closed and goes off when the switch is open. • Observing that chemical energy stored in a battery can be transformed into electrical energy. • Discovering that short circuits are dangerous and produce hot wires/burned fingers. • Observing that plugging in the tape recorder enables the equipment to be turned on. • Observing that tape recorders, saber saws, and other electrically powered devices go on when the switch is closed and go off when the switch is open. • Observing that electricity can be transformed into mechanical energy (saber saw, electric drill, sewing machine, etc.), into heat energy (glue gun, iron, etc.), into chemical energy (battery charger).
Heat/Temperature	• Observing that the dark surfaces near the windows are hotter to the touch than the lighter surfaces. • Observing and measuring changes in temperature by reading a homemade or commercial thermometer.

Heat/Temperature (cont.)

- Observing that some machines (glue gun, electric iron) generate heat when turned on as electrical energy is transformed into heat energy.
- Observing that temperature need not be the same in all parts of the lab room.

Light

- Observing that a glare is produced when a light source shines directly on the chalkboard as light rays are reflected from the shiny, smooth surface.
- Observing that chemical energy of batteries can be transformed into light energy in a flashlight or small lamp.
- Observing that under the same conditions a white-walled side of a room is lighter than a dark-walled side because white-colored walls reflect more light than do black or very dark-colored walls.
- Observing that a lighted area becomes darker when an object is placed between the area and the light source because some light is blocked (reflected or absorbed) by the object.
- Observing that the room is brighter without curtains or shades on the windows because light rays can pass readily through certain (transparent) substances, such as glass.
- Observing that the room is darker with the shades or curtains drawn because light rays are absorbed or reflected by certain opaque substances, such as shades.
- Observing that the side of the room near the windows is brighter than the rest of the room and that the intensity of illumination decreases as the distance from the light source increases.
- Observing that signs, posters, and other written messages may be difficult to read if both the writing and background are similar colors but more easily read if the colors are contrasting (e.g., blue lettering on yellow background).
- Observing that the amount of light present may affect the quality of work being done.
- Measuring light intensity with commercial light meters.

Sound

- Measuring noise levels using professional sound-level meters or tape-recorder meters.
- Observing movement in an object producing sound.
- Observing that classmates located in various parts of the lab room respond to a single spoken direction from

Sound (cont.)

the teacher standing in one location. Sound travels in all directions from the source of the sound.

- Observing that noise from the Design Lab can sometimes be heard in an adjacent room.
- Observing that some of the electrical energy supplied to power tools is transformed into sound energy (noise).
- Observing that sounds differ in tone, pitch, loudness, and quality.
- Observing that noise levels in the lab room are lower when the curtains or acoustical barriers are used to absorb the sound.
- Observing that a sound becomes less intense as the distance from the source becomes greater.
- Observing that sound travels around objects much more readily than light does.
- Observing that different materials absorb sound to different degrees. Solid, dense materials tend to transmit sound well. Soft or porous materials tend to make better sound-absorbing material.

Anatomy/Physiology

- Observing differences in body proportions and strengths when measuring students to find a good size for lab furniture or tools.
- Noting that differences in physical characteristics are important in determining whether lab furniture or tools are comfortable to use.

ACTIVITIES IN DESIGN LAB DESIGN UTILIZING SOCIAL SCIENCE

Process	
Observing/Describing/Classifying	• Observing actions of students during lab sessions. • Organizing and classifying types of Design Lab problems. • Observing and describing effects of noise level, distractions, and any physical disturbances in the lab. • Organizing and classifying sets of ideas or information. • See also MATHEMATICS list: *Classifying/Categorizing*. • See also SCIENCE list: *Observing/Describing; Classifying*.
Identifying Problems, Variables	• Conducting an opinion survey to identify different attitudes students have about the Design Lab and about problems in the Design Lab. • Identifying reasons that materials are wasted, that projects are sometimes destroyed, that lab accidents happen, that time is wasted. • Identifying various needs of different lab users. • See also SCIENCE list: *Identifying Variables*.
Manipulating, Controlling Variables/Experimenting	• Reorganizing lab to reduce overcrowding in some areas, to reduce waste of materials, and to protect projects. • Conducting opinion survey to find out whether new lab arrangement has made lab better. • See also SCIENCE list: *Manipulating, Controlling Variables/Experimenting*.
Inferring/Predicting/Formulating, Testing Hypotheses	• Inferring, from the results of opinion survey, the types of changes that should be made in the Design Lab. • Choosing the best method for organizing materials in the lab based on speed and convenience. • Hypothesizing that if a "touch-and-feel box" were placed in the lab, active students wouldn't meddle with other people's projects. • Inferring from results of opinion survey that the new lab arrangement has reduced the problems in the lab. • Hypothesizing that the results of a survey on a sample of students reflect the opinions of all students. • See also SCIENCE list: *Inferring/Predicting/Formulating, Testing Hypotheses*.

Collecting, Recording Data/ Measuring	• Using voting procedure to determine preferences. • Administering opinion surveys. • See also MATHEMATICS list: *Counting; Measuring.* • See also SCIENCE list: *Measuring/Collecting, Recording Data.*
Organizing, Processing Data	• Tallying votes for workbench or table preferences. • Tallying survey or questionnaire data on opinion of Design Lab before and after changes have been made. • See also MATHEMATICS list: *Organizing Data.* • See also SCIENCE list: *Organizing, Processing Data.*
Analyzing, Interpreting Data	• Comparing qualitative information gathered from interviews with various people. • Determining preferred lab changes by using a rating scale on survey results. • Evaluating survey methodology, size and makeup of sample. • Assessing the predictability of a larger sample (all lab users) based on the results of a smaller sample (the most frequent lab users). • 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, such as preferences for new lab tools, on graphs or charts. • Making charts or graphs that can be easily understood and will have the maximum impact on intended audience, e.g., principal, Design Lab manager, school board. • See also MATHEMATICS list: *Graphing.* • See also SCIENCE list: *Communicating, Displaying Data.* • See also LANGUAGE ARTS list.
Generalizing, Applying Process to Daily Life	• Using knowledge acquired from improving one aspect of the Design Lab to help solve other related Design Lab problems. • Using knowledge acquired from publicizing Design Lab rules and procedure to get people concerned about other problems in the school. • 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., measuring the lab, taking a tool inventory, conducting surveys, finding about safety regulations) are done. • Scheduling hours and personnel at a garage sale held to raise funds to purchase lab tools and materials. • Scheduling and giving presentations to persons in authority, such as the principal or Design Lab manager, to obtain approval for proposed changes in the Design Lab.
Developing Interest and Involvement in Human Affairs	• Promoting a new Design Lab or changes in an existing lab. • Helping younger students or other classes become acquainted with the Design Lab setup and the tools and materials.
Recognizing the Importance of Individual and Group Contributions to Society	• Recognizing that they can set up a Design Lab or improve conditions in the lab. • Recognizing that their work on the Design Lab will help not only themselves but also the school. • Assessing the effects of group action on school regulations.
Developing Inquisitiveness, Self-Reliance, and Initiative	• Conducting group sessions with help from the teacher. • Dealing with various merchants to obtain Design Lab supplies. • Finding their own solutions to problems encountered in addition to the main problem of the challenge. • Choosing and developing the best way of presenting a plan to the principal. • Using the telephone to find out about regulations that might affect plans to rearrange the lab. • Writing to other schools that have Design Labs to find out about their setup and inventory.
Recognizing the Values of Cooperation, Group Work, and Division of Labor	• Finding out that working on improving the Design Lab progresses more rapidly and smoothly when they work in groups. • Eliminating needless overlap in work. • Finding that work is more fun and proceeds more smoothly when people cooperate.

Understanding Modes of Inquiry Used in the Sciences, Appreciating Their Power and Precision	• Using scientific modes of inquiry to investigate and solve problems in the Design Lab. • Using data, graphs, and other supportive material to convince other people that a proposed solution be adopted. • Seeing that various classroom arrangements can be tried by using scale layouts. • See also MATHEMATICS and SCIENCE lists.
Respecting the Views, Thoughts, and Feelings of Others	• Considering all suggestions and assessing their merits. • Considering the opinions of others when proposing a change in the Design Lab setup. • Recognizing that compromise may sometimes be necessary. • Recognizing and respecting differences in values according to age, experience, occupation, income, interests, culture, race, religion, ethnic background. • Respecting the thoughts, interests, and feelings of members of the opposite sex when working in groups.
Being Open to New Ideas and Information	• Considering alternative ways of doing various tasks. • Conducting library research on various aspects of a problem, such as which materials provide good absorption. • Asking other people for opinions, ideas, and information.
Learning the Importance and Influence of Values in Decision-Making	• Realizing that cost effectiveness alone is not sufficient in considering a solution; effects on people must also be considered. • Realizing that preferences for various Design Lab arrangements reflect the values of each individual.

Areas of Study

Economics	• Using concepts and terms such as cost, profit, production cost, and retail price when building furniture or purchasing tools and materials for the Design Lab. • Performing cost analysis of materials. • Gaining experience with finance: sources, uses, and limitations of revenues for the purchase of equipment and materials for the Design Lab. • Assessing preferences, characteristics, etc., of lab users through surveys, questionnaires. • Gaining experience in record keeping and comparative shopping for materials.

Geography/Physical Environment	• Investigating and changing the physical environment in the Design Lab.
Political Science/Government Systems	• Establishing rules for lab users. • Investigating systems of administration and control; deciphering roles of governing persons over the student body. • Investigating regulations and policies affecting planned changes in the classroom. • Working with school authorities to obtain permission to carry out Design Lab plans.
Recent Local History	• Investigating previous attempts to set up or change the Design Lab.
Social Psychology/Individual and Group Behavior	• Recognizing and using different ways of approaching different groups: e.g., using a different approach for fellow students from that for a school board; finding "best" way to approach principal or lab manager about approval for suggested changes in Design Lab.) • Recognizing need for leadership within small and large groups; recognizing differing capacities of individuals for roles within groups. • Analyzing the effects of a small group making decisions for a larger group. • Recognizing that student behavior in the Design Lab may be affected by the number of children working at one time.
Sociology/Social Systems	• Considering the integral, related nature of the school community and its physical surroundings as a factor in the problem of making the Design Lab a better place. • Devising a system of working cooperatively in small and large groups. • Investigating problems and making changes that affect not only themselves but also society (other students in the school, teachers, administration). • Working within established social systems to promote changes within the Design Lab. • Experiencing and understanding differences in social systems in different social groups (children, adults, males, females, homemakers). • Recognizing that there are many different social groups and that one person belongs to more than one social group.

ACTIVITIES IN DESIGN LAB DESIGN UTILIZING LANGUAGE ARTS

Basic Skills

Reading:
Literal Comprehension--Decoding Words, Sentences, and Paragraphs

- Decoding words, sentences, and paragraphs while reading books on sound, catalogs of tools and construction supplies, regulations about fire prevention.

Reading:
Critical Reading--Comprehending Meanings, Interpretation

- Obtaining factual information about sound, tools, construction materials, safety regulations, etc.
- Understanding what is read about sound, tools, construction materials, safety regulations, etc.; learning the meaning of new words.
- Interpreting what is read, for example, books, catalogs, rules and regulations, other people's writing.
- Distinguishing fact from opinion.
- Following written directions.

Oral Language:
Speaking

- Offering ideas, suggestions, and criticisms during discussions in small group work and class discussions on problems and proposed solutions.
- Reporting to class about data collection, scale-drawing activities, construction, etc.
- Responding to criticisms of activities.
- Preparing, practicing, and giving effective presentations to school administrators requesting funds to set up or improve the Design Lab or permission to make changes in the lab.
- Asking questions and phrasing inquiries to elicit desired information.
- Using the telephone properly and effectively to obtain information or to invite a resource person to speak to the class.
- Conducting opinion surveys about possible lab improvements.
- Using rules of grammar in speaking.

Oral Language:
Listening

- Conducting interviews of schoolmates.
- Following spoken directions.
- Listening to group reports, to resource people who speak to the class.

Oral Language:
Memorizing

- Memorizing portions of oral presentations.

Written Language:
Spelling

- Using correct spelling in writing reports, letters, surveys, rules.

Written Language:
Grammar--Punctuation, Syntax, Usage

- Using rules of grammar in writing.

Written Language:
Composition

- Writing to communicate effectively:
  - preparing written reports and letters using notes, data, graphs, charts, etc., communicating need for proposed Design Lab changes.
  - writing posters for the Design Lab.
  - writing opinion surveys; devising questions to elicit desired information; judging whether a question is relevant and its meaning is clear.
  - writing letters to request catalogs, information on tools, or fire and safety information.

Study Skills:
Outlining/Organizing

- Taking notes when consulting authorities or books about sound, tool usage, regulations, etc.
- Developing opinion survey; ordering questions around central themes, such as tool preferences.
- Planning presentations, data collection schemes, etc.
- Planning and preparing drafts of letters, reports for critical review by the class.
- Organizing ideas, facts, data for inclusion in letters, reports, presentations, etc.

Study Skills:
Using References and Resources

- Using the library to research for information on sound, fire and safety regulations, etc.
- Using dictionary and encyclopedia to locate information.
- Using indexes and tables of contents in books to locate desired information.
- Finding an expert on soundproofing or safety standards and inviting him or her to speak to the class and answer questions.
- Using "How To" Cards for information on making a scale drawing, using tools, etc.
- Using catalogs to find information about Design Lab items.

Attitudes/Values

Appreciating the Value of Expressing Ideas Through Speaking and Writing	• Finding that classmates and teacher may approve of an idea if it is presented clearly. • Finding that the school will allocate money when presented with an adequate (written or oral) proposal.
Appreciating the Value of Written Resources	• Finding that certain desired information can be found in books on sound, in catalogs on tools.
Developing an Interest in Reading and Writing	• Willingly looking up information on sound, tools, regulations. • Looking up additional or more detailed information. • Showing desire to work on drafting letters or reports.
Making Judgments Concerning What is Read	• Deciding whether what is read is applicable to the particular problem. • Judging reliability of information obtained from reading. • Deciding whether the written material is appropriate, whether it says what it is supposed to say, whether it may need improvement, whether it is fact or opinion.
Appreciating the Value of Different Forms of Writing, Different Forms of Communication	• Finding that how information can best be conveyed is determined in part by the audience to whom it is directed. • Finding that certain data or information can best be conveyed by writing it down, preparing graphs or charts, etc. • Finding that certain data or information should be written down so that it can be referred to at a later time. • Finding that spoken instructions are sometimes better than written instructions, and vice versa.