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ABSTRACT

This module, one in a series of performance-based teacher education learning packages, focuses on a specific skill that vocational educators need in order to integrate the teaching and reinforcement of basic skills into their regular vocational instruction. The purpose of the module is to give educators competency in assisting students in improving their math skills. It provides techniques for (1) assessing students' math skills in relation to the math requirements for the occupational area, (2) assessing one's own readiness to assist students with these skills, and (3) working with students to improve math skills. The teacher also gains skill in identifying specific kinds of errors students commonly make and in helping students to improve skills in these specific areas. Introductory material provides terminal and enabling objectives, a list of resources, and general information. The main portion of the module includes three learning experiences based on the enabling objectives. Each learning experience presents learning activities with information sheets, samples, checklists, and case studies. Optional activities are provided. Completion of these three learning experiences should lead to achievement of the terminal objective presented in the fourth and final learning experience. The latter provides for a teacher performance assessment by a resource person. An assessment form is included. (YLB)

Assist Students in Improving Their Math Skills

AMERICAN ASSOCIATION FOR VOCATIONAL INSTRUCTIONAL MATERIALS

THE NATIONAL CENTER FOR RESEARCH IN VOCATIONAL EDUCATION

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION

FOREWORD

This module is one of a series of 127 performance-based teacher education (PBTE) learning packages focusing upon specific professional competencies of vocational teachers. The competencies upon which these modules are based were identified and verified through research as being important to successful vocational teaching at both the secondary and postsecondary levels of instruction. The modules are suitable for the preparation of teachers and other occupational trainers in all occupational areas.

Each module provides learning experiences that integrate theory and application; each culminates with criterion-referenced assessment of the teacher's (instructor's, trainer's) performance of the specified competency. The materials are designed for use by teachers-in-training working individually or in groups under the direction and with the assistance of teacher educators or others acting as resource persons. Resource persons should be skilled in the teacher competencies being developed and should be thoroughly oriented to PBTE concepts and procedures before using these materials.

The design of the materials provides considerable flexibility for planning and conducting performance-based training programs for preservice and inservice teachers, as well as business-industry-labor trainers, to meet a wide variety of individual needs and interests. The materials are intended for use by universities and colleges, state departments of education, postsecondary institutions, local education agencies, and others responsible for the professional development of vocational teachers and other occupational trainers.

The PBTE curriculum packages in Category M—Assisting Students in Improving Their Basic Skills—are designed to enable vocational teachers and other occupational trainers to integrate the teaching and reinforcement of basic skills into their regular vocational instruction. The modules are based upon 85 teacher competencies identified as essential for vocational teachers to teach and to reinforce basic communication, computation, and employment skills as part of the ongoing occupational education program.

Many individuals and institutions have contributed to the research, development, testing, and revision of these significant training materials. Appreciation is extended to the following individuals who, as members of the DACUM analysis panel, assisted National Center staff in the identification of the teacher competency statements upon which this category of modules is based: Milton Arnold, Lewis Cain, William Chandler, Jim Frazier, Jackie Marshall, Teresa Paige, Thomas Peterson, Marie Schemitz, and Nancy Underwood.

Field testing of the materials was carried out with the assistance of field-site coordinators, teacher educators, students, directors of staff development, and others at the following institutions: University of Alabama-Birmingham; Albuquerque Technical-Vocational Institute, New Mexico; University of Central Florida; Dupage Area Vocational Education Authority, Wisconsin; Holland College, P.E.I., Canada; Seminole Community College, Florida; University of Southern Maine; and Temple University, Pennsylvania.

Special recognition for major individual roles in the development of these materials is extended to the following National Center Staff: Lucille Campbell-Thrane, Associate Director, Development Division, and James B. Hamilton, Program Director, for leadership and direction of the project; Lois G. Harrington and Michael E. Wonacott, Program Associates, for module quality control; Cheryl M. Lowry, Research Specialist, for developing illustration specifications; Barbara Shea for art work; Adonia Simandjuntak, Graduate Research Associate, for assistance in field-test data summarization; and Catherine C. King-Fitch and Michael E. Wonacott, Program Associates, for revision of the materials following field testing.

Special recognition is also extended to the staff at AAVIM for their invaluable contributions to the quality of the final printed products, particularly to Donna Pritchett for module layout, design, and final art work, and to George W. Smith, Jr. for supervision of the module production process.

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The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research.
- Developing educational programs and products.
- Evaluating individual program needs and outcomes.
- Providing information for national planning and policy.
- Installing educational programs and products.
- Operating information systems and services.
- Conducting leadership development and training programs.

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The institute is a cooperative effort of universities, colleges and divisions of vocational and technical education in the United States and Canada to provide for excellence in instructional materials.

Direction is given by a representative from each of the states, provinces and territories. AAVIM also works closely with teacher organizations, government agencies and industry.

MODULE

M-5

Assist Students in Improving Their Math Skills

Module M-5 of Category M—Assisting Students in Improving Their Basic Skills

PROFESSIONAL TEACHER EDUCATION MODULE SERIES

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INTRODUCTION

Everyone uses mathematics at one time or another; most of us use it every day. In our personal lives, we follow a recipe, weigh ourselves, measure a room. As consumers, we decide whether we have enough money to buy something, count our change, figure mileage, balance a checkbook.

As job applicants, we take employment tests, figure salary and benefits, plan the time needed to get to an interview on schedule. On the job, we do everything from counting to computing to using geometric principles, depending on the occupation. In today's technological world, a person without basic math skills is sorely handicapped.

Unfortunately, some students reach secondary or postsecondary vocational-technical training without possessing needed skills in math. Somewhere along the way, most math-deficient students have had trouble with math, have gotten increasingly behind in the subject, and have eventually given up, deciding that they "just couldn't do math."

It is the aim of vocational-technical instruction to prepare students who are employable and who can succeed in their chosen occupations. Since your students will need basic math skills to be successful both as consumers and as workers, helping students who need to improve their math skills is part of your responsibility as a vocational-technical instructor. While intensive math remediation should be left to the specialists, there are many things you can do within the context of your regular instructional program to help students improve their math.

This module is designed to give you competency in assisting students in improving their math skills. You will learn techniques for (1) assessing students' math skills in relation to the math requirements for the occupational area, (2) assessing your own readiness to assist students with these skills, and (3) working with students to improve their math skills. You will also gain skill in identifying specific kinds of errors that students commonly make and in helping students to improve their skills in these specific areas.

ABOUT THIS MODULE

Objectives

Enabling Objectives:

1. After completing the required reading, devise a method of assessing students' proficiency levels in the math skills required for a selected unit of instruction in your own occupational specialty (*Learning Experience I*).
2. After completing the required reading, plan appropriate techniques to help students described in given case situations to improve specific math skills (*Learning Experience II*).
3. Given a case study describing how a vocational teacher assisted students in improving their math skills, critique the performance of that teacher (*Learning Experience III*).

Prerequisites

The modules in Category M are not designed for the prospective teacher with no prior training and/or experience. They assume that you have achieved a minimal level of content knowledge in your occupational specialty and skill in the core teacher competencies of instructional planning, execution, and evaluation. They then build on or expand that knowledge and skill level, specifically in terms of assisting students in improving their basic skills.

Resources

A list of the outside resources that supplement those contained within the module follows. Check with your resource person (1) to determine the availability and the location of these resources, (2) to locate additional references in your occupational specialty, and (3) to get assistance in setting up activities with peers or observations of skilled teachers, if necessary. Your resource person may also be contacted if you have any difficulty with directions or in assessing your progress at any time.

Learning Experience I

Optional

Reference: Boyce, John; Slade, Samuel; and Margolis, Louis. *Mathematics for Technical and Vocational Schools*. Sixth Edition. New York, NY: Wiley Publishing, 1975.

A basic mathematics textbook used in your school or college that you can use as a reference.

A math specialist from whom you can obtain information and resources for assisting students in improving their basic math skills, given the math requirements for your particular occupational specialty.

Learning Experience II

Optional

Reference: Gleason, James R. Mathematics Learning Activity Packages. Columbus, OH: The Ohio State University, Interstate Distributive Education Curriculum Consortium (IDECC), 1981.

Learning Experience III

No outside resources

Learning Experience IV

Required

An actual teaching situation in which you can assist students in improving their math skills.

A resource person to assess your competency in assisting students in improving their math skills.

General Information

For information about the general organization of each performance-based teacher education (PBTE) module, general procedures for its use, and terminology that is common to all the modules, see About Using the National Center's PBTE Modules on the inside back cover. For more in-depth information on how to use the modules in teacher/trainer education programs, you may wish to refer to three related documents:

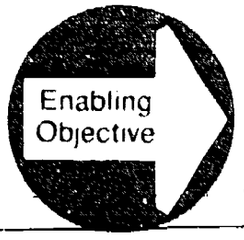
The *Student Guide to Using Performance-Based Teacher Education Materials* is designed to help orient preservice and inservice teachers and occupational trainers to PBTE in general and to the PBTE materials.

The *Resource Person Guide to Using Performance-Based Teacher Education Materials* can help prospective resource persons to guide and assist preservice and inservice teachers and occupational trainers in the development of professional teaching competencies through use of the PBTE modules. It also includes lists of all the module competencies, as well as a listing of the supplementary resources and the addresses where they can be obtained.

The *Guide to the Implementation of Performance-Based Teacher Education* is designed to help those who will administer the PBTE program. It contains answers to implementation questions, possible solutions to problems, and alternative courses of action.

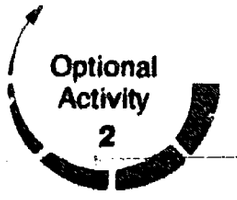
Learning Experience I

OVERVIEW



After completing the required reading, devise a method of assessing students' proficiency levels in the math skills required for a selected unit of instruction in your own occupational specialty.

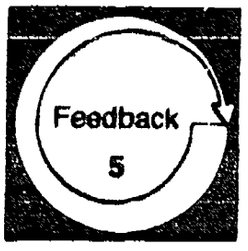
You will be reading the information sheet, Improving Basic Math Skills in Vocational Education, pp. 7–17.



You may wish to refresh your knowledge and skill in basic mathematics by reviewing a math textbook such as the following: Boyce et al., *Mathematics for Technical and Vocational Schools*. Or you may wish to review a basic mathematics textbook used in your school or college.

You may wish to consult a math specialist to obtain information and resources for assisting students in improving their basic math skills, given the math requirements for your occupational specialty.

You will be identifying the math skills required for achieving the student performance objectives in a selected unit of instruction in your occupational specialty.



You will be evaluating your competency in identifying required math skills by completing the Math Skills Checklist, pp. 19–20.

You will be developing an activity for assessing students' levels of proficiency in the math skills you identify.

You will be evaluating your competency in developing an activity for assessing students' levels of proficiency in the required math skills identified by completing the Assessment Activity Checklist, pp. 21–22.

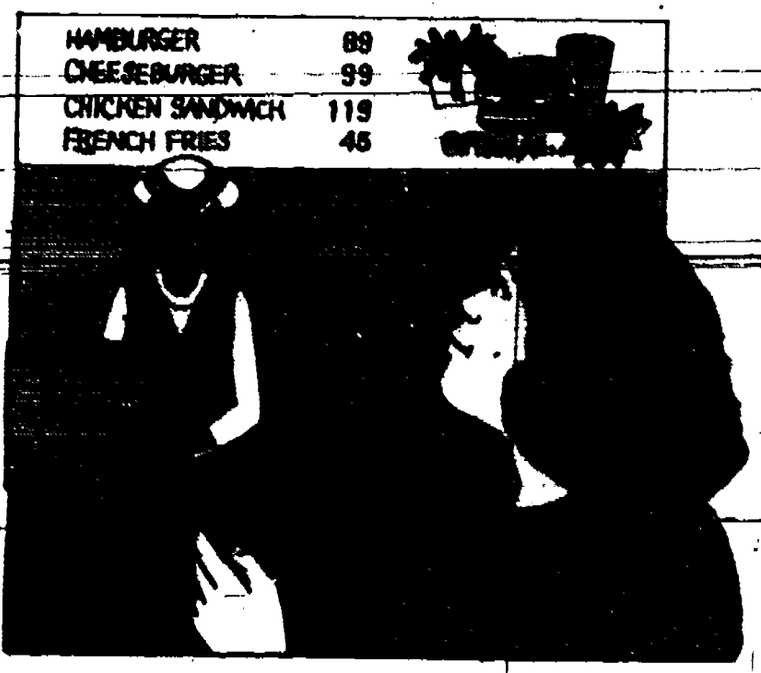
Activity 1

Some of your students may lack the basic math skills required for entry into their chosen occupations. For information on how you can help them to improve their basic math skills, read the following information sheet.

IMPROVING BASIC MATH SKILLS IN VOCATIONAL EDUCATION

How often do you use math from day to day? Could you get along without it? Picture yourself on an average day with no math skills. You wouldn't be able to decide whether you had enough money to buy gas, or coffee, or lunch. You couldn't count your change, pay a bill, follow a recipe, estimate a length or distance, balance a checkbook, or fill out a time sheet or order form.

Carried to the extreme, you would have to have a job in which you never had to count, read or write numbers, recognize a number as being larger or smaller than another, add, subtract, multiply, divide, measure, and so on. Pretty farfetched? Most adults, you might say, can count and compare numbers. Anyone knows that 10 is larger than 2, right? But how about 1/32 and 1/8? Which is larger? Or .50 and 1.00? Or 3/4 and .75?



You may have students in your class who lack some of the math skills that are considered to be basic. If the skills they lack are needed on the job in the occupational area for which they are preparing, your students may be in trouble.

Even if they could get by on the job without being able to work math problems in conventional ways, they might never get a chance to try. Many employers require job applicants to pass an employment test—including math problems—before they will even interview them. An applicant who can't multiply 37 × 48 may never get a chance to show that he or she can run a machine, make a sale, or type a business letter with ease.

Your Role

You may feel that you shouldn't have to be responsible for teaching basic math. After all, you're trying to teach your students to operate machines, make sales, type letters, or gain other job skills.

Isn't it the math teacher's job to teach basic math? Isn't it your job to prepare students for employment? True enough, but if your students need to be able to use basic math in order to enter the occupation, you must be involved to some extent in developing their math skills.

Does this mean that you should stop everything and teach remedial math? No, of course not. You probably have neither the time nor the training to do so. But if your students need to improve their basic math skills in order to perform on the job, there are ways you can help them in the course of your regular instruction.

As a vocational teacher, you may even have an advantage when it comes to adding a little "painless" math instruction to your lessons. Many students who have done poorly in math are afraid of it. It may seem complicated and utterly "academic"—an obstacle in school and irrelevant in adulthood.

"I'll never need to know a numerator from a denominator after I leave this place," they may say. Or, "The square of the hypotenuse won't put money in my pocket; why bother with it?"

Such attitudes often result from a series of early failures. Having failed at mastering math in the early grades—for whatever reasons—students may come to think that they just can't do it. They then avoid taking any more math, or even any courses that include math. By avoiding math, they get further and further behind.

But presented in simple terms, in small doses, and—most important—in a practical, job-related context, math may seem less difficult, less threatening, and more worthwhile to your students. If they are interested in the vocational-technical program and care about getting a job when they finish, this may motivate them to learn the math they will need. If you address each math skill in terms of its practical use on the job, your students should come to realize how relevant these skills really are.

Basic Math Skills

What are basic math skills? If you were to ask two math specialists, two vocational educators, two employers, and a couple of people on the street, you might get eight different answers, for example:

- "Problem solving is the real fundamental."
- "Computation skills are the basics."
- "Basic skills have changed since hand-held calculators, computers, and automated cash registers became a part of our lives."

Depending on who is talking, any given math skill may be "basic," "necessary," "helpful," or "nice to know."

One way of looking at the whole question is to ask yet another question: basic to what and for whom? For the elementary school math teacher, basic may mean fairly comprehensive mathematical thinking and all its subsidiary skills (addition, subtraction, and so on).

But we are not talking about laying the foundations of mathematical understanding for elementary-age students. Your students are preparing to leave school and enter the world of work—ideally with whatever math skills they will need.

As a vocational-technical instructor, you will be concerned with the kinds of math used by workers in your occupational area. The math skills needed on the job may differ from one occupational area to another.

For example, in a merchandising program, students work with costs, quantities, markups, discounts, and so on—which call for a lot of computation and problem-solving skill. Working with computations involving fractions and decimals needs to be almost second nature. In commercial foods, measuring ingredients, understanding equivalents, and increasing and decreasing recipes are among the skills that are emphasized. In shop fabrication, geometry is important.

Each occupational area is a little different, so the basics vary somewhat also. Generally speaking, however, there are some math skills that underlie the ability to perform others—if students can't do these, they won't be able to do the others. For many occupational areas, students need the following math skills in order to succeed in the program and on the job.[1]

Quantification. This includes reading and writing numbers, counting, and ordering numbers (putting numbers in sequence, recognizing whether one number is bigger or smaller than another).

Computation. Computation requires the ability to add, subtract, multiply, and divide. Most people need to be able to compute with single- and multiple-digit whole numbers, mixed numbers, fractions, and decimals.

Measurement and estimation. Measurements (of time, temperature, distance, length, volume, height, weight, velocity, speed, and so on) are used by almost everyone. Most students need to be able to take measurements, use them, and report them properly.

In some instances, an exact measurement may not be necessary or practical. It may be more appropriate to estimate or to approximate. To do this, one needs to know simple techniques for estimating such things as quantities, length, and distance, and to have a sense of the accuracy needed for the purpose at hand.

Problem solving. Math skills ultimately are useful for one purpose: to solve real problems. But the math skills discussed previously—quantification, computation, measurement, and estimation—are not, by themselves, sufficient to solve problems. Outside the classroom, problems usually are not found as sets of numbers on a sheet of paper, with directions for completing them. They turn up most often in situations.

To put math skills to work on a problem, one has to be able to (1) recognize the problem, (2) distinguish useful from irrelevant information, (3) determine whether more information is needed, (4) determine what mathematical steps can be used to solve the problem, (5) set up the problem in a workable format, and (6) compute the answer.

Comprehension. To be able to quantify, compute, measure, estimate, and solve problems, the student may need to draw upon knowledge and skill in four areas:

1 The delineation of fundamental skills is adapted from Cornell Institute for Occupational Education, *Teaching Mathematics Skills in Vocational Education* (Ithaca, NY.: Cornell Institute for Occupational Education, 1980).

- **Equivalents**—Many math skills depend on an understanding of how measurements on different scales relate to each other (e.g., metric and English, fractions and decimals, feet and yards, ounces and pounds).
- **Organization of data**—Students' success may often depend on their understanding different ways numerical data are displayed (e.g., graphs, scales, schedules, tables, charts); being able to collect, organize, and interpret data; and developing the confidence not to be intimidated by sheer mass of numbers.
- **Algebra**—For some areas, students need to be able to set up and solve equations and to understand the relationship of equations to problem solving.
- **Geometry**—Some occupations require the ability to use geometric principles and formulas to determine angles, area, volume, perimeter, and so on.

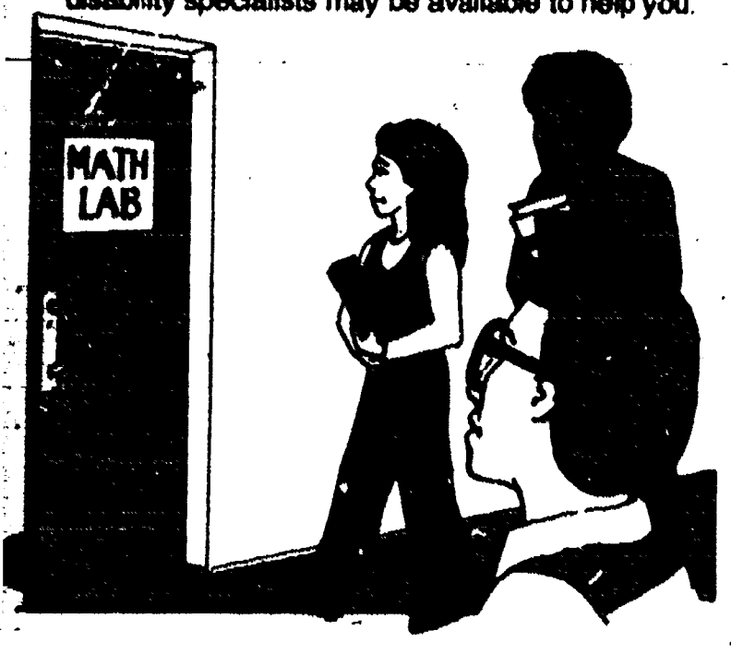
Specific Strategies

This probably seems like a lot of math. How can you include all these math skills as part of your regular instruction? It may be helpful to keep several points in mind

First, we are talking about improving math skills, not teaching remedial math. You are not going to take on the responsibility of teaching your students everything they need to know about basic math. You will be helping them to improve in specific areas where their skills are deficient.

Second, students in your occupational area may not need all the skills listed. One of the first steps you will need to take is to determine just what skills they do need and in which skills individual students need help.

Finally, help is available. Math specialists in your institution can help you by providing advice, texts, references, assessment devices, math exercises, games, and other activities to use with your students. If you have students with special learning problems, special education teachers or learning disability specialists may be available to help you.



There may be cases in which a student's math skills are so poor that you feel it is beyond your capacity to help the student. In those situations, it would probably be best to arrange for remedial instruction by a math specialist and to provide supportive activities in your own class.

Assisting students in improving their basic math skills has two phases: **preparation** (during which you make the necessary assessments) and actually **working with the students.** Let's explore some general strategies you can use in the two phases of this process.

Prepare to Assist Your Students

Before you can begin helping your students to improve their math skills, you will need to prepare for the task by assessing the situation and your readiness to meet it. You will need to assess the following:

- What math skills students will need as they pursue their occupational goals
- Students' competency levels in relation to the required skills
- Your own readiness to teach those skills
- The adequacy of your instructional materials for meeting students' needs

Let's look at each of these assessments separately.

Assess the math requirements. As part of your instructional planning, you will probably have used occupational analyses or competency profiles to identify the minimum competencies required for entry into occupations in your vocational-technical area. You will also have identified the long-range goals of the students enrolled in your program. From these two bodies of information, you will have derived the competencies to be covered in your instruction and the learning objectives for individual students.

The next step is to identify the math skills required for mastering the competencies. Perhaps the math skills have already been analyzed for your area. Many such analyses have been done for specific occupations on national, state, and local levels. If you are not sure whether one is available in your area, you can check with your professional organization, state department of education, departmental chairperson, or your resource person.

If no such analysis can be obtained, you can do your own assessment. You first need to review the occupational analyses or competency profiles and identify competencies that involve math: computation, measurement, estimation, problem solving, use of numerical data, and so on.

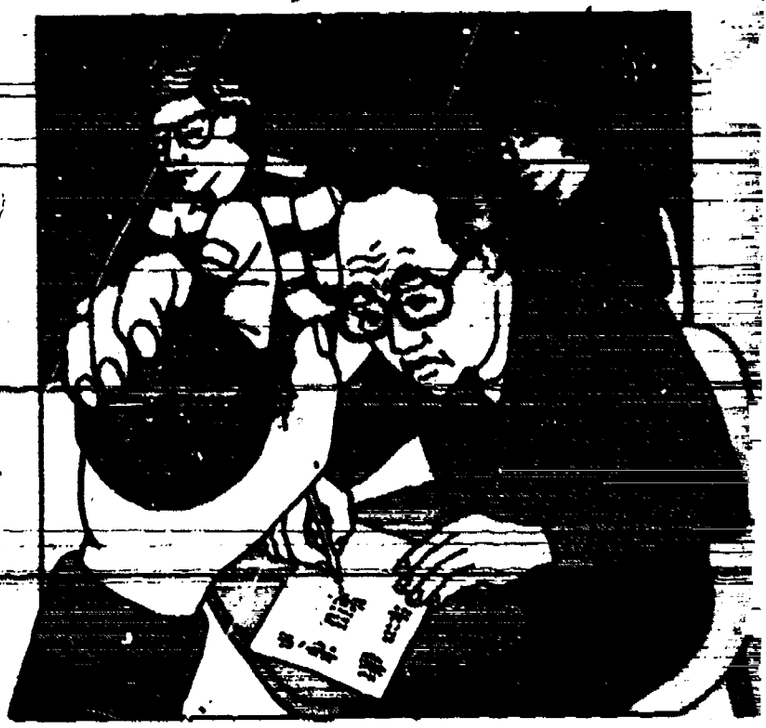
Then, for each of these competencies, you need to determine what specific skills are involved. For example, increasing a recipe might require multiplication of whole numbers and fractions, understanding of equivalents, use of charts, and some problem-solving ability.

You may find it helpful to work with a math teacher in analyzing the math skill levels needed for the various occupational tasks. However, for your purposes, it isn't really necessary to analyze the math skills in a great deal of detail. Therefore, the required skills should be fairly easy to identify on your own.

Assess students' present levels of skill in math. Having identified the entry-level math requirements, you then need to assess students' competency levels in relation to those requirements. You can do this formally or informally.

Use of a **formalized testing approach** is a common method of assessing math skills. A math specialist may have applicable tests or be willing to help you put together a test appropriate for your specific program. However, a few words of caution about using formalized testing for this purpose are in order here.

First, a student who dislikes or fears math because of a history of negative experiences with the subject may simply freeze up when faced with a whole page of problems. A testing situation or a mass of number problems can trigger anxiety, and as a result, the student may be unwilling to try to solve the test problems. If so, the test results probably will not give you a true picture of his or her abilities.



Second, tests to measure basic math skills frequently focus on computation skills—the most easily assessed of the math skills—and ignore the rest. For example, the ability to use mathematical problem-solving skills in real situations may be overlooked, even when such skills are crucial on the job.

At best, problem-solving ability may be tested through word problems. But when typical word problems are used in this way, other factors may affect the students' performance. For example, a student with reading difficulties may not be able to decipher the problem, even though he or she might be able to do so in a real situation.

Or, if the word problem is not relevant to what the student is learning in the program, a necessary element of motivation may be missing. The student may simply not care enough to figure out how many bushels of wheat the farmer will have for market in some hypothetical set of circumstances.

Beyond this, most word problems simply do not test problem-solving skills such as identifying a problem in its natural context, distinguishing relevant from irrelevant information, and so on. Most word problems present the problem, with just the right information, and with key words to suggest what steps to take. In a sense, everything is laid out except the computation.

If you do choose to use formalized testing, the following suggestions can help you to minimize problems such as these:

- Keep tests short. If a student is having trouble with one or two problems, why give the student ten problems of the same type? If you have many different skills to assess, it may be better to give several short tests at different times than to administer one long test.
- Be sure reading levels, vocabulary, and testing methods match your students' capabilities. Be aware of the reading difficulties and other special needs of individual students. Try alternative approaches that meet their needs, such as giving word problems orally.[2]
- Make sample problems realistic and relevant to your program and students' occupational interests.
- Try to make the testing situation a positive, nonthreatening experience. Explain the purpose and procedures of the test clearly. Review vocabulary if necessary. Explain the relationship of math abilities to the rest of the instructional program.
- Afterward, review the results of the test with each student. In order to pinpoint specific difficulties, go over each problem the student got wrong, and have the student explain the process he or she used to solve each problem.
- Show students how to self-evaluate. Let them participate in deciding where they need additional help. Taking responsibility for this decision may help them to approach the subject constructively.

You may choose to limit formal testing and to take an **informal approach.** Such an approach might, in fact, give you information that is more useful for your purposes than a more formal approach. By focusing on the ways math is really used on the job, you can devise informal situations to assess students' abilities to perform the related math.

For example, you might decide to have students do individual shop projects. You could ask them to figure out the exact materials (type, size, amount) they will need for their projects and to come to you with their orders. By reviewing—with the students—their orders and their methods of arriving at them, you could assess their abilities in a given set of math skills. From this and similar situations, you could determine student needs in relation to basic math and derive a set of learning objectives for each student.

2. To gain skill in selecting testing methods that are appropriate for students' special needs, you may wish to refer to Module L-9, *Assess the Progress of Exceptional Students.*

Assess your own skills. For you to make math simple and clear to your students, it must be simple and clear to you. But it would not be uncommon, when stepping outside an occupational specialty and into an area like math (which we tend to take pretty much for granted at the basic level), for you to find yourself saying something like, "I can do it, but I can't really explain just how I do it."

You will need to assess your knowledge and competency in the math skills you have identified. This should include the following:

- Your understanding of the underlying concepts
- Your ability to perform the mathematical operations
- Your ability to help your students learn those operations

You can test yourself informally by working sample problems and trying to explain how you worked them. It may also be helpful to review a basic math text to refresh your memory or refine your skills. Again, a math specialist can serve as a valuable resource in your self-assessment and in helping you brush up wherever necessary.

Assess existing materials. With the required math skills and the students' present skill levels in mind, you will need to review your instructional materials. In determining whether they are adequate for improving basic math skills, you should consider the following questions:

- Do they cover math skill development adequately, or do they assume basic math proficiency and go on to more complex math skills?
- Do they present basic math in ways that are appropriate for your students' learning needs? (For example, do they use communication channels—auditory, visual, or kinesthetic—through which individual students learn best? Are reading and complexity levels appropriate? Are the organization and pace suited to the students' attention spans and ability to focus?)
- Are explanations clear and simple?
- Do the materials provide enough opportunity for practice?
- Are the practice problems relevant to your students' interests? Are they relevant to your program?
- Is the material presented in a way that is appealing and nonthreatening?

Based on your assessment, you may need to adapt your materials or to locate other materials to supplement or replace them. For example, you might revise existing materials to include more detail, to simplify explanations, to reduce the reading level, or to make sample problems more relevant to your students' interests.

Or you might decide to supplement some materials, adequate as far as they go, with additional materials. Perhaps adding visuals would be helpful. Some students might simply need additional practice problems to acquire the skill needed. Adding more enjoyable activities might make the material more appealing to students who are reluctant to try.[3]

Once again, support personnel—specialists in math, special education, and learning disabilities—may be available to help you in assessing math materials and locating other appropriate resources.

Work with Students

When you know what math skills your students need and where they need help in improving those skills, the question becomes how to help them within the context of your vocational-technical program. The specific strategies you use will depend on your occupational area and the math skills your students need. However, regardless of these factors, there are several **general strategies** you can use to help your students.

- Create a positive atmosphere.
- Individualize instruction.
- Teach math in the context of occupational skill development.
- Use visual and tactile means to reinforce math concepts.
- Provide practical math activities.

Let's look at each of these strategies in more detail.

Create a positive atmosphere. We have talked about the role of fear and anxiety in math deficiency. Creating a positive atmosphere is essential for overcoming negative attitudes that may stand in the way of improving students' math skills. You probably already use a variety of positive approaches in your regular instruction. The same approaches, reviewed here, will serve well in the context of improving basic math skills.

First, and perhaps most important, is to **project a positive attitude.** You need to show that you have confidence that your students can learn math. While a positive attitude on your part won't guarantee your students' success, a negative attitude will very likely contribute to their failure. Since math deficiency is often at least partly attitudinal, breaking down the attitudinal barriers may be a major step in enabling your students to open their minds to mathematical concepts. Your confidence can help to inspire a positive attitude on their part.

A second approach that is closely related to projecting a positive attitude is to **create a nonthreatening environment.** Mathematics by nature is exacting: an answer to a problem is either right or wrong. Unfortunately, some students see their math experience as a lot of years of wrong answers. For a student with this view of math, trying again may seem very threatening.

Students who feel threatened may find it helpful to have math presented in your program as a means to an end—their occupational goals—rather than as an end in itself. Setting up competency-based learning objectives may also help because it allows students to focus on achieving specific math competencies rather than on whether they will pass or fail a math test.

There are other techniques you can use to help sustain a nonthreatening environment. Focusing on what is right rather than on what is wrong is very important. For example, picture yourself working a problem at the board. Instead of turning around, calling on Mary, and putting her on the spot for an answer, you could keep your back to the students and have them call out answers anonymously. Then, ignoring all the wrong answers, you might say, "That's right, 47 is the answer." Being wrong simply becomes unimportant in this situation.

Another nonthreatening technique is to play down the potential for being wrong. It may be just a matter of choosing your words carefully to reduce anxiety. For example, you might refer to "your answer" rather than "the answer."

3. To gain skill in evaluating, adapting, or developing materials to meet students' special needs, you may wish to refer to Module L-4, *Provide Appropriate Instructional Materials for Exceptional Students.*

Say, for instance, that you have given a problem and are calling on individual students: "John, what's your answer?" "Amy, what answer do you have?" As answers are given, you could write all of them on the board, randomly, right or wrong. Then you could work the problem on the board, ignore all the wrong answers, and reinforce the right one. No one in this situation is penalized for being wrong, and everyone sees how your answer is obtained.

A third approach to creating a positive atmosphere is to **encourage students to take responsibility** for improving their own math skills. That is, you want to encourage them to make a conscious decision that they need to improve their skills and that they will work toward that improvement. The final responsibility for learning must be theirs. You can help them improve by providing instruction, materials, and assistance, but only they can do the learning and the practice that are required for skill development.

To make this kind of commitment, the students must be motivated. They need to understand just how important math is to them. Each student in your program has an occupational goal. It may be helpful to discuss with your students specific ways in which math relates to their goals. For example, you might review some of the job duties related to a student's occupational goal, pose hypothetical on-the-job situations, and have the student consider how well he or she would get along with his/her present levels of math skill.

Some students may be better motivated by seeing the importance of math for outside interests (e.g., understanding batting averages, figuring materials needed for a hobby, even playing poker) or for getting along as a consumer. For example, you could say to students something like the following: "You're on your own, you've got a job, and you're making money. You can finally buy that color television you've been wanting. Are they going to come and take it away in three months because you didn't understand the interest rate for the installment purchase and can't make the payments?"

For other students, such topics as earnings, paychecks, overtime, bonuses, and getting ahead may be the key. Knowing your students' interests will help you determine how to motivate them to take responsibility for improving their math skills.

Students are also more likely to take responsibility for math skills improvement if they take part in the assessment and decision-making process. Students who evaluate their own performance and determine where they need help are much more likely to take the help seriously and to work toward achievement.

You could, for example, involve a student in reviewing the math skills analysis for the chosen occupational goal, taking a skill test for the required math, assessing his or her own performance, and identifying weak areas. The student would then need to decide whether he or she wants to work to improve in the weak areas in order to pursue the long-range goal. If so, the student could then take part in setting his/her own learning objectives.

A student who participates in this kind of process is likely to feel a greater sense of responsibility for achieving the objectives than a student who is simply told that he or she needs to improve. And the atmosphere is going to be much more positive when students are working toward **chosen** goals.

Another way to create and sustain a positive atmosphere is to **build on success.** This can help to increase students' confidence in themselves. The assessments that you have done will show not only what the students can't do, but what they can do. This is a good place to start. You can focus on the students' present skills by giving them problems you know they can handle. Then you can reinforce their success and point out practical applications for the math they already know.

For example, if you have a student who can add multiple-digit whole numbers fairly well, you might point out how this skill applies to balancing a checkbook, totaling a sales check, and so on. Or you might choose to give the student tasks such as these on which to demonstrate his or her ability.

As your students' confidence grows from realizing what they can do, you can gradually work up to new skills. Of course, in order to build on success, students need to **experience** success with each new skill. As you introduce new material, you should be looking for ways to foster success.

One strategy is to prepare the students properly for each new skill. For some students, reviewing new vocabulary will help them to understand a new concept. Relating new ideas to known concepts is also very helpful.

For example, *100 yards* might be meaningless to a student until he or she relates it to the length of a football field. Staying with the sports analogy for a moment, a student who isn't grasping the concept of division might already understand the concept of "half the distance to the goal line" without having recognized it as division.

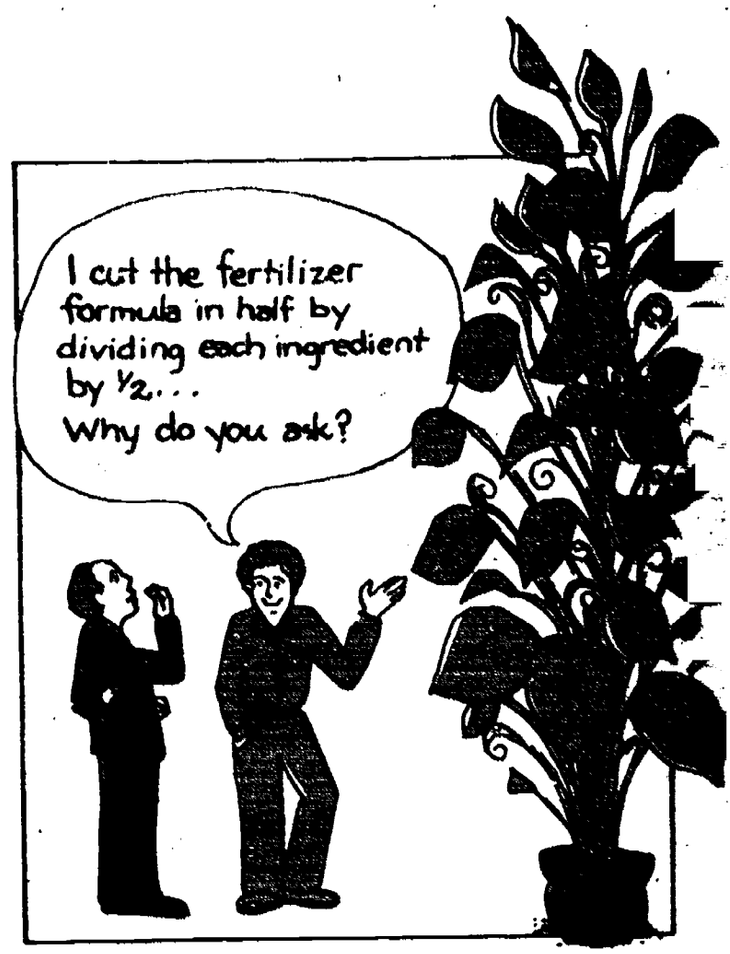
It is also important to avoid overwhelming students with problems they can't handle. It can be very discouraging for a student who is struggling with a new concept to see thirty problems on a sheet of paper. It would be far better to let the student try one or two problems. Then, when the student is ready, you can give more problems for reinforcement.

Finally, an important part of creating a positive atmosphere is to **make learning enjoyable.** For most students having trouble with math, math has never been fun. But if you are confident your students can succeed, if the environment is nonthreatening, if your students want to learn, and if they are experiencing some success—if all these conditions are met, then improving their math skills at least will not be a negative experience. You can make it even more positive by choosing learning activities that are enjoyable for the students.

Games, brainteasers, tricks, and shortcuts for solving certain kinds of problems can be more fun—and, in some cases, more instructive—than working a page of problems. A math teacher can probably help you locate a variety of enjoyable activities that you can tie in with your instruction.

Knowledge of your field will probably give you material you can use to create hypothetical job situations involving math. It can be both fun and instructive, for example, for students to figure out what went wrong, mathematically, to cause the person in the hypothetical situation to arrive at a silly outcome.

Another way of making math enjoyable is to keep students' interest high by relating math to things in which you know they have an interest—hobbies, sports, home-life, career goals, and so on.



When you really get the students involved, you can take advantage of their interest level by stopping the activity midstream—while interest is still high—and picking it up later. In the meantime, they might even spend some time **thinking** about what you were working on.

Individualize instruction. If you are teaching in a competency-based vocational program, you will find it quite natural to individualize instruction for math skills improvement in the same way that you have done so for the rest of your program. If you are in a more traditionally organized program that employs primarily group instruction, you still may find it helpful—even necessary—to individualize the math portions of your instruction.

We have discussed the importance of assessing occupational math requirements and students' related abilities in order to set learning objectives. We have also noted the need for a positive atmosphere to enhance students' commitment to achieving their objectives. Naturally, you will also want to plan your instruction so that it enables each individual student to meet his/her objectives. In addition, you may find that individualization permits you to meet students' needs with the least interruption to your ongoing program.

In planning how you will assist students in improving their math skills, you may find it helpful to keep the following guidelines in mind:

- Instruction should contribute directly to each student's long-range occupational goals and immediate objectives for math skills improvement. The students' learning objectives will dictate what you teach. Whether you use group or individual instruction for specific portions of the content will depend to a large extent on how many students need help in a given area.
- Learning activities should be varied and should permit each student to begin at the appropriate level and proceed at his or her own rate.
- Instructional strategies should be consistent with students' individual needs with regard to learning style and preferred grouping.

  For example, one student might respond to a one-to-one explanation of a skill that is giving him or her trouble—say, multiplying fractions. Another might need practice in multiplying fractions to refine his or her skill. Perhaps learning activity packages, a game, a simulation, or repeated practice on supervised laboratory tasks would help this student.
- Evaluation procedures should allow each student to be evaluated when ready. Opportunities for self-evaluation should be provided to encourage in students an ongoing sense of responsibility for their own progress.

  Since checking one's answers is a good practice in math, methods for doing so should be taught with each computation skill. Self-evaluation can be used as a natural outgrowth of this process.
- Students' vocational-technical interests may serve as the basis for individualized instruction. If you capture their interest with something that "hits home," you may well accomplish that sometimes-difficult task of motivating individuals.

  For example, is a student in a hospitality management program dreaming of running a fishing lodge one day? By having that student plan the facilities and staffing for such a lodge, the instructor could give him/her a lot of practice on basic math skills.
- Personal interests—leisure activities, home interests, hobbies, and so on—may also be good sources of math activities. For example, if one of your students is a displaced homemaker with small children, you could come up with many problems related to family budgeting. For a student who puts a lot of time into working on cars, you could devise problems related to costs of parts, speed, RPMs, horsepower, fuel costs, and so on.[4]

Teach math in the context of occupational skill development. As a vocational-technical instructor, your main task is to prepare students for entry into their chosen occupations. If your students need to improve their math skills for job entry, you will need to look for ways to incorporate math into other areas of your instruction.

As we have already discussed, weaving math into your ongoing instruction will benefit both you and your students. For you, it will reduce the amount of extra time required beyond your regular vocational-technical subject matter. For your students, math for a specific purpose will have more relevance than math as a separate subject. It is likely, therefore, to be more interesting, and it may be easier to understand as well.

As part of your math skills analysis for the occupation, you will have identified tasks in which math is used. These tasks are the most likely context for teaching math. Your own situation will dictate how you incorporate the math, but let's look at an example of how it can be done.

Imagine that students in a clothing program are going to learn about altering patterns, and the instructor knows that one student is having trouble with fractions. Without taking advantage of this context, the instructor could decide just to plug in a remedial unit on the related math before getting into pattern alterations with that student. (Using this approach, chances are that the instructor would either turn off or scare off the student.)

4. To gain additional skill in individualizing instruction, you may wish to refer to Module C-18, *Individualize Instruction.*

On the other hand, the instructor might devise a way to work the math **into** the unit on alterations. Here's an example. Beginning with the importance of proper fit, the instructor might show pictures of women wearing improperly fitted clothing. He or she might then describe a set of measurements that do not correspond to any given pattern size and ask questions such as the following: How would this person look in a size 12? How would you make a size 12 fit her properly?

Then, as the instructor explains how to make specific adjustments (for example, evenly reducing the pattern 2 inches in the hips), he or she could give the struggling student extra help with fractions.

You can see that the difference between the two approaches is that, in the second, the additional math help was given as a part of the occupational skill being learned, not as a separate math unit. As such, it probably would have had more meaning and purpose for the student.

Use visual and tactile means to reinforce math concepts. A major stumbling block for some students is their inability to relate mathematical concepts to things they already know. Math by nature is symbolic. To really grasp the underlying meaning, students have to be able to "see" the symbolism. And they need to see that mathematical facts are true no matter what objects they are applied to—that the sum of 8 and 4 is 12, whether cans or inches are being added.

There are many ways to make the relationships clear. One is to use physical objects for demonstrating math concepts and to have students manipulate those objects. Hands-on experience is one of the most effective means of learning math concepts.

Say, for example, that a carpentry instructor is talking about dividing a board into equal lengths. Demonstrating this concept by dividing an actual board into 6 equal lengths may be much clearer than dividing 12 by 6 on a chalkboard. Having students do the measuring and cutting would be even more effective. You can probably think of many other examples in your own area—using money, cups of flour, containers of water, lengths of yard goods, quantities of nails, or whatever objects are appropriate.

Visual demonstrations using such aids as counters, pie charts, graphs, or folded paper are also helpful ways for clarifying math concepts. The more the students manipulate these materials themselves, the better their chances of understanding the concepts.

Another visual technique, which we have already talked about, is to relate mathematical ideas to concepts the students already know. For example, how long is 15 millimeters? Some students would draw a blank. But, compare it to 16mm film, and students who have handled movie film will probably get a rough idea.

Endless examples could be given for visual techniques. You can probably think of many that naturally occur in your instruction.

Provide practical math activities. You are already aware of some of the disadvantages of using typical word problems to provide practice in problem solving in the vocational-technical classroom. For many reasons, they tend to be an ineffective test of problem-solving skills and often seem irrelevant to the vocational-technical skills the students are learning.

However, your class or lab is a natural source of **real** problems to be solved through math. Situations that arise on the job or in daily living can also be simulated in class to give students practice in asking themselves the right questions:

- What do I need to find out?
- What do I already know that can help me find the answer?
- What more do I need to know in order to find the answer?
- How can I use what I already know to find out more?
- What is the solution?

The student who can ask the right questions is more likely to be able to solve problems on the job using other math skills (computation, algebra, and so on).

You can probably identify many problems that arise in your vocational-technical area that can be solved mathematically:

- Increasing or decreasing formulas or recipes
- Planning amounts of materials needed for specific shop projects
- Predicting results of changes in speed, velocity, temperature, or other variables
- Predicting inventory needs
- Computing budgets

You can use problems such as these to demonstrate on-the-job problem solving. Sample 1 shows how problem-solving questions and related math can be applied to a classroom problem (in this case, buying fabric for draperies).

SAMPLE 1

APPLIED PROBLEM SOLVING

Figuring Drapery Fabric

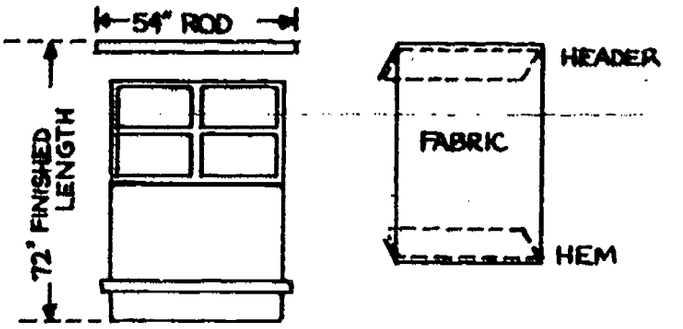
What do I need to find out?

How much fabric should I buy?

What do I already know?

3 identical windows, sizes as shown

Finished length:	72 in.
Header allowance:	3 in. + 3 in. = 6 in.
Hem allowance:	3 in. + 3 in. = 6 in.
Total width:	face of rod + 12 in.
Fabric width:	44 in.



What other information is needed?

Unfinished drapery length per window
Number of panels per window

How can I use available information to learn more?

Unfinished length = finished length + header allowance + hem allowance

72 + 6 + 6 = 84" unfinished length

Panels per window = $\frac{\text{total width} \times 2}{\text{fabric width}}$

54 + 12 = 66" total width

66 x 2 = 132"

44 | 132 → 3 panels per window, -132

What is the solution?

Amount of fabric needed = unfinished length × number of panels per window × number of windows

84 x 3 x 3

84 x 3 = 252; 252 x 3 = 756"

756 inches / 36 inches per yard

36 | 756 → 21 yards of fabric needed; -72; 36; -36

As students participate in solving these kinds of problems, they become better able to use their skills independently. This is important: it will allow them to solve problems that arise later on the job.

Problems related to personal interests and daily living can also provide the same kind of practice. For example:

- Planning a schedule to get specific things done in a given amount of time
- Reconciling a bank statement with the check book register
- Figuring interest on an installment purchase
- Figuring total, tip, and tax on a salescheck and splitting the check among several people

If time permits, you might have each student bring such a problem to be solved by the class. The class can work together to set up the problem, identify available and needed information, and compute the answer.

If you are interested in improving your own skills and knowledge of basic mathematics, you may wish to review a basic mathematics textbook used in your school or college.

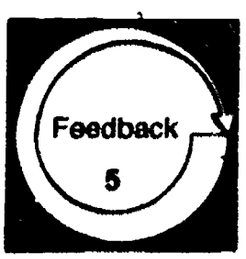
Another option is to review pertinent sections of the following supplementary reference: Boyce et al., *Mathematics for Technical and Vocational Schools.* This text is written in simple language and is intended for people who will be working with tools and machinery. Chapters 1 through 4 deal with common fractions, percentages, and ratios and proportions. Also addressed are geometry, graphs, measuring instruments, and a variety of industrial applications of math. Sample problems are vocationally oriented.

If you desire additional help in preparing to assist your students in improving their basic math skills, you may wish to consult a math specialist. Such a specialist may be able to provide the following kinds of assistance:

- Sample assessment devices or assistance in devising your own means of assessment
- Assistance in evaluating instructional materials for basic math skills improvement
- Advice and resources for adapting or supplementing existing materials
- Sources of basic math materials and activities related to your content area

You should be able to locate a math specialist who can help you within the math department of your own school or college.

Assume that you are teaching in a vocational-technical program in your own occupational specialty. Identify a unit of instruction in your program that requires the use of math skills. Then, identify the particular math skills required for students to achieve the student performance objectives in the selected unit of instruction. Be sure to include not only broad areas of math skill (e.g., computation), but also specific skills (e.g., addition of whole numbers).



After you have identified the math skills required for students to achieve the student performance objectives in a selected unit of instruction, use the Math Skills Checklist, pp. 19–20, to evaluate your work.

MATH SKILLS CHECKLIST

Directions: Place an X in the NO, PARTIAL, or FULL box to indicate that each of the following performance components was not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, a performance component was not applicable, place an X in the N/A box.

Name _____

Date _____

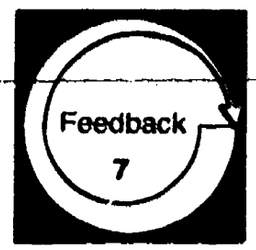
Resource Person _____

	LEVEL OF PERFORMANCE			
	N/A	No	Partial	Full
In identifying the required math skills, you:				
1. reviewed the student performance objectives included in the unit of instruction	☐	☐	☐	
2. identified broad areas of math skill required for achieving the objectives, including the following, as appropriate:				
a. quantification	☐	☐	☐	
b. computation	☐	☐	☐	
c. measurement	☐	☐	☐	
d. estimation	☐	☐	☐	
e. problem solving	☐	☐	☐	
f. comprehension of equivalents	☐	☐	☐	
g. organization of data	☐	☐	☐	
h. algebra	☐	☐	☐	
i. geometry	☐	☐	☐	
3. identified specific math skills needed for achieving the objectives, including, as appropriate, the ability to:				
a. read and write numbers, count, and order numbers	☐	☐	☐	
b. add, subtract, multiply, and divide whole numbers	☐	☐	☐	
c. add, subtract, multiply, and divide fractions and mixed numbers	☐	☐	☐	
d. add, subtract, multiply, and divide decimals	☐	☐	☐	
e. make, use, and report measurements (e.g., of time, temperature, or other units pertinent to the specific objectives to be achieved)	☐	☐	☐	
f. estimate measurements and quantities	☐	☐	☐	
g. use problem-solving techniques in solving on-the-job problems	☐	☐	☐	

	N/A	No	Partial	Full
h. relate measurements on different scales (e.g., metric and English, fractions and decimals, feet and yards, or other scales used in the selected unit of instruction)	☐	☐	☐	
i. apply algebraic and geometric principles to practical, on-the-job problems	☐	☐	☐	

Level of Performance: All items must receive FULL or N/A responses. If any item receives a NO or PARTIAL response, review the material in the information sheet, Improving Basic Math Skills in Vocational Education, pp. 7–17, or check with your resource person if necessary.

For the unit of instruction you selected, **develop in writing** an activity for assessing students' levels of proficiency in the math skills required to achieve the student performance objectives in that unit. Your activity may include written tests and/or other classroom or lab activities through which you can assess proficiency in the identified skills.



After you have developed your assessment activity, use the Assessment Activity Checklist, pp. 21–22, to evaluate your work.

ASSESSMENT ACTIVITY CHECKLIST

Directions: Place an X in the NO, PARTIAL, or FULL box to indicate that each of the following performance components was not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, a performance component was not applicable, place an X in the N/A box.

Name _____

Date _____

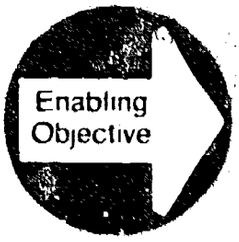
Resource Person _____

Your assessment activity:	LEVEL OF PERFORMANCE			
	N/A	No	Partial	Full
1. includes one or more of the following assessment devices:				
a. informal situations devised to assess students' ability to perform the required skills	☐	☐	☐	
b. existing tests covering the required skills	☐	☐	☐	
c. tests specially developed to assess the required skills	☐	☐	☐	
2. covers all the math skills identified within the selected instructional unit	☐	☐	☐	
3. includes activities/test items that focus on ways the identified math skills are actually used on the job	☐	☐	☐	
4. includes activities/test items that require students to apply problem-solving techniques	☐	☐	☐	
5. includes problems that are realistic and relevant to:				
a. the selected unit of instruction	☐	☐	☐	
b. students' vocational interests	☐	☐	☐	
6. provides opportunities for self-evaluation	☐	☐	☐	
7. includes one or more of the following strategies for making the situation as nonthreatening as possible:				
a. presenting the activity/test in the context of regular activities	☐	☐	☐	
b. explaining the relationship of math to other program activities	☐	☐	☐	
c. using just one or two problems to test each math skill	☐	☐	☐	
d. using several short activities/tests rather than one long one	☐	☐	☐	
e. ensuring that reading levels, vocabulary, and testing methods match students' capabilities	☐	☐	☐	
f. explaining assessment purposes and procedures in advance	☐	☐	☐	
g. reviewing vocabulary, if needed	☐	☐	☐	
h. reviewing assessment results with each student	☐	☐	☐	

Level of Performance: All items must receive FULL or N/A responses. If any item receives a NO or PARTIAL response, review the material in the information sheet, Improving Basic Math Skills in Vocational Education, pp. 7–17, or check with your resource person if necessary.

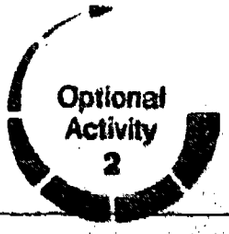
Learning Experience II

OVERVIEW



After completing the required reading, plan appropriate techniques to help students described in given case situations to improve specific math skills.

You will be reading the information sheet, Improving Specific Math Skills, pp. 24–46.



You may wish to review vocationally oriented student and teacher materials designed to improve specific math skills, such as the Mathematics Learning Activity Packages produced by the Interstate Distributive Education Curriculum Consortium (IDECC).

You will be reading the Case Situations, pp. 47–50, and planning appropriate techniques to help the students described to improve specific math skills.

You will be evaluating your competency in planning appropriate techniques to help students improve specific math skills by comparing your responses with the Model Responses, pp. 51–52.

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Activity 1

Once you know what basic math skills your students need and where they need help, there are a variety of techniques you can use to help them improve in specific skills. By and large, you can do this within the context of your regular vocational-technical content. For information on helping students to improve specific math skills, read the following information sheet.

IMPROVING SPECIFIC MATH SKILLS

Let us say that, through your assessment activities, you have identified math skills that your students need to improve. You have assessed your own math skills and are prepared to work with the students individually and in a positive atmosphere. How can you do this in the context of your ongoing vocational-technical program?

First, you will need to identify exactly where each student is having trouble so that you can give each student just the kind of help he or she needs. There are several things you can then do to help students improve specific math skills:

- Pinpoint the difficulty.
- Use simple explanations, visual aids, and manipulative activities to explain mathematical concepts.
- Work on specific problem areas and build to the larger skill.
- Provide practice activities.

Let's take a closer look at each of these tasks in relation to specific math skills.

Pinpoint the Difficulty

Your initial assessment is usually confined to the broader areas of math with which your students need help. For example, an instructor might have found initially that one of his/her marketing and distributive education students was having difficulty making *extensions*. The student needs this skill for figuring discounts, quantity prices, and the tax in completing an invoice. In the instructor's assessment, he/she found that the student was having trouble multiplying fractions and decimals.

But the instructor still needs more information. Does the student need the basics of multiplication? Are multiplication tables the problem? Or is it something like carrying numbers or placing decimal points?

One way to pinpoint the problem more specifically is to **use diagnostic tests.** You may be able to obtain such tests from a math specialist. They are designed so that the student's pattern of right and wrong answers shows exactly what part of the operation the student is doing incorrectly.

Another way to pinpoint the difficulty is to **develop a checklist** of the component skills, or subtasks, with which to "zero in" on the problem area. You can develop such checklists by listing the math applications—from simple to complex—used in your program and the subtasks that make up those applications. It may also be helpful to review a basic math text to identify subtasks. Samples 2 through 4 illustrate checklists for selected math applications.

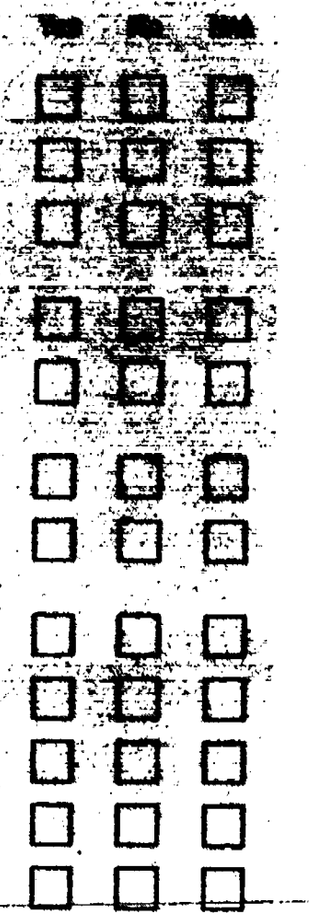
The subtasks involved in mathematical problem solving may be less easily defined. In general, they will reflect the basic problem-solving steps (determining what you need to find out, what you already know that is useful, what more you need to know to solve the problem, and so on). But the specific subtasks will vary because they will be closely tied to the particular problem being solved. Sample 5 shows the subtasks for mathematically solving a given occupational problem.

SAMPLE 2
MATH CHECKLIST

Adding Whole Numbers

The student:

1. demonstrates knowledge of the basic addition facts .....
2. adds a single column of whole numbers on paper .....
3. adds whole numbers mentally .....
4. adds multiple-digit whole numbers:
   a. lines up numbers correctly .....
   b. starts with right-hand column, works left .....
   c. adds two digits in the column at a time, gets a sum, and adds the next number to it .....
   d. writes total sum for column directly below column .....
   e. if sum has two digits, writes only the second digit under the column and carries the first digit to the next column .....
   f. adds "carried over" digits when totaling the column .....
   g. repeats process for each column .....
   h. for final (left-hand) column, writes both digits of sum to complete the answer
   i. checks answer by adding in reverse direction .....



You can develop checklists such as those shown in samples 2 through 5 for any math competencies that you identify in your occupational area. With the math operations broken down into subtasks in this manner, it should be easy to pinpoint what skills and subtasks are giving students trouble.

Another way to pinpoint difficulties is to **have students demonstrate how they work problems.** If you have a student who is having trouble with division, for example, it can be very enlightening just to watch the student work a few division problems. If you discovered the student's difficulty initially through a test, you could simply follow up by having the student show you the process he or she used in solving those division problems. With your checklist of division subtasks in hand or in mind, it should be fairly easy to pinpoint where the student needs to improve.

One student might need help with the basic number facts. Another might need to review the whole concept and process of division. Still another may simply be getting hung up on a particular subtask, such as bringing down numbers or inserting zeros. It would be pointless to give each of these students a detailed explanation of how division works. By pinpointing the trouble, you can tailor your instruction to each student's needs.

SAMPLE 3

MATH CHECKLIST

Reading and Reporting a Measurement

The student:	Yes	No	N/A
1. uses the appropriate measuring instrument (e.g., ruler, tape, micrometer) for the length to be measured and the degree of accuracy needed	☐	☐	☐
2. places the instrument correctly	☐	☐	☐
3. reads the measurement correctly	☐	☐	☐
4. if necessary, converts measurement to more practical units (usually by multiplying or dividing)	☐	☐	☐
5. identifies units of measure in the reported measurement	☐	☐	☐

SAMPLE 4

MATH CHECKLIST

Using a Tax Table to Determine Tax on Taxable Items

The student:	Yes	No	N/A
1. uses correct subtotal for taxable items	☐	☐	☐
2. finds correct dollar column on one axis of table	☐	☐	☐
3. finds correct cents range on other axis	☐	☐	☐
4. reads tax amount where columns intersect	☐	☐	☐
5. enters tax properly on sales check	☐	☐	☐

SAMPLE 5

MATH CHECKLIST

Determining the Cost Per Serving of a Given Food

The student:	Yes	No	N/A
1. uses a portioning chart to find the standard portion or serving	☐	☐	☐
2. determines the size of package in which the item is bought	☐	☐	☐
3. determines the number of servings in that size package	☐	☐	☐
4. determines the price of that size package (e.g., if 6 packages cost $10.74, divides $10.74 by 6 and determines that the cost per package is $1.79)	☐	☐	☐
5. determines the price per serving by dividing the price of the package by the number of servings in the package	☐	☐	☐

Explain Mathematical Concepts

You are likely to find that some students really do lack basic understanding in one or more areas of math. Perhaps a student can't handle division because he or she has never really understood the relationship between multiplication and division. Such a student will need some basic groundwork before he or she will be able to handle the division process very well.

You will have to decide whether you can provide the help the student needs or whether you should refer the student to a specialist for more intensive instruction. If you do refer the student, you will probably want to plan some supportive activities to use in your own program.

If you determine that you can assist the student, you need to plan learning activities that include the following:

- Simple, clear explanations and basic rules
- Explanations or applications related to program content
- Demonstrations of step-by-step procedures
- Visible or tangible teaching aids
- Manipulative activities

Sample 6 shows an excerpt from a handout incorporating several of these strategies, which might be used in an automotive program to help explain a math concept. The handout could be used in combination with an oral explanation, a chalkboard demonstration, and the use of real objects.

Manipulating objects is another effective way for a student to learn underlying math concepts. You can probably think of many hands-on activities appropriate to your own program that could be used to teach math concepts. For example:

- Adding coins, nails, or the inch markings on a ruler
- Subtracting money, pipe lengths, or patient input output
- Multiplying ingredients, tax, or stock
- Dividing a board length, a pie, or a template into equal parts
- Measuring wire, floor space, or paper
- Folding paper or fabric into equal parts or geometric shapes

One point you will need to consider in teaching math basics is how much your students **really** need to know for occupational competency. Take, for example, definitions or labels. Your students may not really need to know the terms *multiplier*, *multiplicand*, and *product*.

On the other hand, you may decide that using those terms makes it easier for you to teach the process of multiplication. In that case, you would probably explain the terms so that the students would know what you are talking about. But you would probably not require them to know the terms in order to demonstrate competency in multiplication.

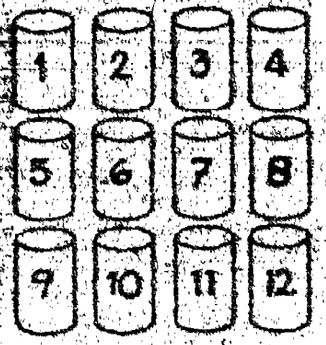
SAMPLE 6

MATH HANDOUT

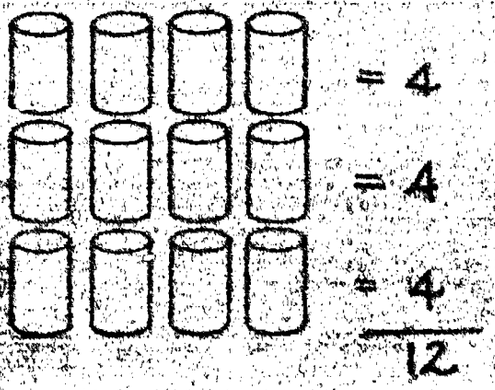
Multiplication

You need to know how many quarts of oil are on hand in the garage.

There are 3 rows of cans. Each row has 4 cans in it. You could count each can and find that you have 12 cans.



Or, you could add 4 + 4 + 4 and get 12 cans.



But what if you have 17 cases and each case holds 24 cans? Counting and adding are going to take longer. The larger the numbers, the less convenient it is to count or add. Then it's more convenient to multiply.

Multiplying is a short way of adding numbers. Instead of adding a column containing the number 24 seventeen times, you can multiply 24 × 17 and get the same answer. Let's review the basic rules for multiplication.

Basic Rules:

- Only 2 numbers can be multiplied at a time.
- The order in which you multiply them doesn't matter (4 × 7 is the same as 7 × 4).
- Multiplying by 1 doesn't change the number (5 × 1 = 5).
- Multiplying by 0 always equals 0 (5 × 0 = 0).

Multiplication Tables:

If you are going to do multiplication problems, you will need to know the multiplication tables. The chart below shows all the combinations from 2 to 10. . . .

Procedures:

Now let's look at some sample problems. . . .

Work on Specific Problem Areas

We have talked about starting at the beginning—the basic math concepts—for students who have a real gap in their mathematical knowledge. For many students, however, this would be both unnecessary and ineffective. A student who is turned off by math may just stop listening when you start talking about fundamentals. Besides, the trouble spot may not be that basic.

Another approach is to begin right where the student is having problems. Imagine that a student is showing you how she solves an addition problem and you see that she isn't carrying numbers correctly. That's a good place to start. If you work with her on carrying numbers, you may find that her overall skill in addition improves significantly. By building competency in the subtasks, the student builds competency in the larger skill.

Basic Number Facts as a Problem Area

We all know that you can't do math unless you know basic number facts ($4 + 5 = 9$, $7 \times 7 = 49$, and so on). The number facts for addition and subtraction usually are not a big problem because they only involve combinations from 0 to 10. Multiplication facts, of course, are another matter; they seem to be a major stumbling block for most math-deficient students.

This presents a dilemma for a teacher trying to help students improve their math skills. Do you work with the students to help them learn the number facts? Or do you help them find shortcuts—ways to get around learning the tables? Or do you perhaps try to do both?

It may be unrealistic to expect some students who are having trouble with math to memorize multiplication facts at this stage of the game. It may have been the insistence that they must learn their tables that created the barrier in the first place.

Then how do you help these students? The answer lies partly in the **occupational math requirements.** If the worker is going to have to recall number facts quickly in order to do on-the-spot calculations, then there may be no way around learning the tables. In other job situations, using shortcuts and aids may be an acceptable alternative.

For example, you might suggest that your students refer to a multiplication **number chart** (see sample 7) as they do their math. Most students will quickly learn some of the easier combinations, such as the 2s and the 5s. By using the chart, they are apt to learn other combinations to which they refer often. Number charts can also be used for addition and subtraction, as shown in samples 8 and 9.

You might also suggest that the students count on their fingers, make lines on paper, or construct a **number line** (see sample 10) if they need to.

Hand-held **calculators** are another option. You may argue that a person is better off having the facts handy—in his or her own head—than depending on a calculator. This is probably true, but if the calculator makes the difference between being able to work math problems and not being able to (and especially if calculators can be used on the job), then the calculator can be a valuable tool. In fact, research has shown that the use of calculators helps, rather than hinders, learning.

Besides, student use of calculators is increasing dramatically. As calculators have become smaller and less expensive, many more students have gained access to them. Some even have them built into their wristwatches.

So, you are likely to have students who are going to use calculators no matter what you decide about their appropriateness. But students shouldn't depend totally on a calculator, because things can go wrong. A student may push the wrong button or not push hard enough. A student may push two buttons at once or the same button twice. Or the battery may be weak.

Ability to estimate is the key to recognizing whether the calculator's answer is correct. (If a student expects an answer to be somewhere around 4,000 and gets an answer around 4,000,000, it should be clear to him or her that something is wrong.) And in order to estimate, students need to know basic number facts.

Consequently, whether or not calculators and charts can be used on the job, knowledge of the number facts is still valuable. Learning those facts through memorization, flash cards, and other rote methods is effective with some students.

SAMPLE 7

MULTIPLICATION NUMBER CHART

Directions: To multiply two numbers, find one number along the top edge and the other along the left edge. Run your fingers along the two rows until they meet.

Example: 4 × 5

- Find 4 on the top edge.
- Find 5 on the left edge.
- The "4" row (going down) meets the "5" row (going across) at 20. The answer is 20.

	2	3	4	5	6	7	8	9	10
2	4	6	8	10	12	14	16	18	20
3	6	9	12	15	18	21	24	27	30
4	8	12	16	20	24	28	32	36	40
5	10	15	20	25	30	35	40	45	50
6	12	18	24	30	36	42	48	54	60
7	14	21	28	35	42	49	56	63	70
8	16	24	32	40	48	56	64	72	80
9	18	27	36	45	54	63	72	81	90
10	20	30	40	50	60	70	80	90	100

SAMPLE 8

ADDITION CHART

Directions: To add two numbers, find one number along the top edge and the other along the left edge. Run your fingers along the two rows until they meet.

Example: 8 + 4

- Find 8 on the top edge.
- Find 4 on the left edge.
- The "8" row (going down) and the "4" row (going across) meet at 12. The answer is 12.

	1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10	11
2	3	4	5	6	7	8	9	10	11	12
3	4	5	6	7	8	9	10	11	12	13
4	5	6	7	8	9	10	11	12	13	14
5	6	7	8	9	10	11	12	13	14	15
6	7	8	9	10	11	12	13	14	15	16
7	8	9	10	11	12	13	14	15	16	17
8	9	10	11	12	13	14	15	16	17	18
9	10	11	12	13	14	15	16	17	18	19
10	11	12	13	14	15	16	17	18	19	20

SAMPLE 9

SUBTRACTION CHART

Directions: To subtract two positive numbers, find the *minuend* along the top edge and find the *subtrahend* along the left edge. Run your fingers along the two rows until they meet.

Example: 7 − 4 (7 is the minuend; 4 is the subtrahend)

- Find 7 along the top edge.
- Find 4 along the left edge.
- The "7" row (going down) meets the "4" row (going across) at 3. The answer is 3.

Minuends

Subtrahends	1	2	3	4	5	6	7	8	9	10
1	0	1	2	3	4	5	6	7	8	9
2		0	1	2	3	4	5	6	7	8
3			0	1	2	3	4	5	6	7
4				0	1	2	3	4	5	6
5					0	1	2	3	4	5
6						0	1	2	3	4
7							0	1	2	3
8								0	1	2
9									0	1
10										0

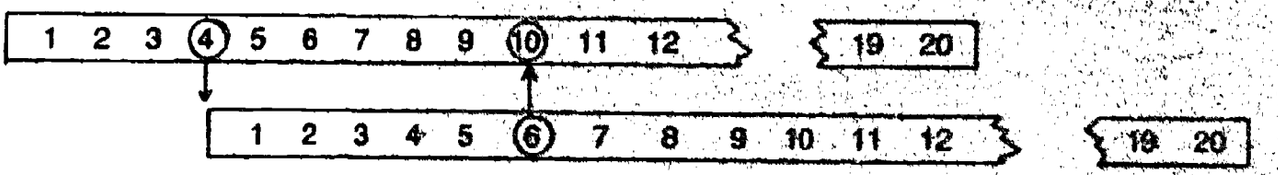
SAMPLE 10

NUMBER LINES

Number lines are two separate, movable strips of paper (rulers can also be used). They are moved in relation to each other to add or subtract.

Example: 4 + 6

- **Place two number lines on the table, one above the other.**
- **Find 4 on the first line.**
- **Place the front end (the zero point) of the second number line directly below the 4 on the first line.**
- **Find 6 on the second line and read the number above it on the first line. The answer is 10.**



- **To subtract, reverse the process.**

However, rote methods may repel other students and actually prevent them from learning. For these students, using memory aids (charts and calculators) may not seem to them like a tedious learning exercise. Thus, they may retain at least some of the most commonly used combinations, so that they eventually refer to the aids less. As students learn their number facts, timed quizzes recorded on a chart to show progress may also help students retain these facts.

Beyond these methods, a few **hints** may help your students. For example, you might point out that addition and multiplication combinations are the same in reverse. Students need to know that if 7 + 5 escapes them, they can turn it around, maybe 5 + 7 is easier. Likewise, 7 × 5 is the same as 5 × 7.

You can also suggest that students move up or down a notch on their mental tables when they get stuck. For example, if 8 × 6 is hard, they need to know that they can try 8 × 5 and then add another 8. The trick with both of these strategies is for students to learn to work from what they **do** know.

Computation Problem Areas

Aside from lack of basic number facts, other problem areas may surface. Once identified, such problem areas usually can be easily corrected. The following are some typical problem areas related to computation and some strategies for improving students' skills in these areas.

Addition of whole numbers. Problems with addition often result from not understanding place values or from misunderstanding the procedures for carrying numbers. The following are typical errors:

- **Lining up the numbers incorrectly**—In this problem, the student lined up the numbers on the left instead of on the right. This gave the numbers 8 and 2 values of 80 and 20.

```
 47
  8
 36
+ 2
-----
 183
```

- **Forgetting to carry**—The student added 7 + 8 + 6 + 2 and got 23. Instead of writing the 3 and carrying the 2, the student wrote 23. This gives a sum of 723 instead of 93.

```
  47
   8
  36
+  2
-----
 723
```

- **Carrying the wrong number**—The student added 7 + 8 + 6 + 2 and got 23. Instead of writing the 3 and carrying the 2, the student wrote 2 and carried the 3. This gives a sum of 102 instead of 93.

```
 ³47
   8
  36
+  2
-----
 102
```

It may help students to review the concept of place values and procedures for carrying numbers. They should be able to see the problem in this way:

```
 47 = 40 +  7
  8 =       8
 36 = 30 +  6
  2 =       2
     70 + 23 = 93
```

As the students work problems, they should be encouraged to write carried numbers legibly above the column so they don't forget to add them in. And they should check all answers by adding again in the opposite direction.

Many students also find it helpful to group numbers for easier mental or written addition. Using this strategy, students look for easy-to-handle combinations of numbers, especially 10s. Sample 11 illustrates an addition problem solved using the grouping method. Although this sample is written out to show the process used, in actual practice the student would not necessarily write out the entire process. The groupings could be done mentally or with brief notations.

Subtraction of whole numbers. Borrowing tends to be the most difficult aspect of subtraction and the area where most students have trouble. Below are some of the mistakes that students frequently make.

- **Lining up the numbers incorrectly**—In this problem, the student aligned the numbers on the left instead of on the right. This gives 347 a value of 3470. The answer of 1790 is quite different from the correct answer of 4913.

```
 5260
-347
------
 1790
```

- **Subtracting a number from zero and getting the same number**—Here the student subtracted 7 from 0 and got 7, instead of borrowing and then subtracting 7 from 10.

```
 5260
-  347
------
 4827
```

SAMPLE 11

GROUPING NUMBERS IN AN ADDITION PROBLEM

SAMPLE PROBLEM:

47
53
62
56
36
21
+ 19

SOLUTION:

1. GROUP NUMBERS

15 =	4, 5, 6	7, 3	= 10
		2	= 2
10 =	5, 3, 2	6, 6	= 12
1 =	1	1, 9	= 10

2. ADD RIGHT COLUMN AND CARRY

10
2
12
(3) 10

carry 4

3. ADD LEFT COLUMN

15
10
1
(+3)

29 4 = 294

- **Subtracting the top number from the bottom number**—The student subtracted 2 from 3, instead of borrowing and then subtracting 3 from 12.

$$\begin{array}{r} 5260 \\ -\ 347 \\ \hline 5113 \end{array}$$

- **Neglecting to borrow**—This student didn't borrow to make it possible to subtract 7 from 10. Instead, the student tried to subtract 7 from 0 (impossible) and decided the answer must be 0. The same mistake was made in trying to subtract 3 from 2.

$$\begin{array}{r} 5260 \\ -\ 347 \\ \hline 5020 \end{array}$$

- **Forgetting to decrease the number borrowed from**—This time the student borrowed and correctly subtracted 7 from 10 to get 3. But then, instead of decreasing the 6 and subtracting 4 from 5, the student subtracted 4 from 6. The same mistake was repeated in borrowing from the 5.

$$\begin{array}{r} 5260 \\ -\ 347 \\ \hline 5923 \end{array}$$

- **Neglecting to borrow from more than one place value**—This student should have borrowed from three place values in order to subtract 3 from 10, 0 from 9, 0 from 9, and 6 from 8. Instead, the student borrowed incorrectly from one place value.

$$\begin{array}{r} 49{,}000 \\ -\ 6{,}003 \\ \hline 43{,}097 \end{array}$$

It may help your students to review the concept of place values and the basic rules of subtraction (e.g., always work from right to left; be sure the top number is bigger; and remember that subtracting 0 from a number does not change the number). Demonstrating the procedures for borrowing is also important. In addition, you should encourage students to do the following:

- Write in the borrowed and decreased values as they work, to lessen chance of error.

$$\begin{array}{r} {}^{4}\not{5}\,{}^{5}\not{2}60 \\ -\ 347 \\ \hline 4913 \end{array}$$

- Check all answers by adding the answer and the bottom number to get the top number.

$$\begin{array}{r} 347 \\ +\ 4913 \\ \hline 5260 \end{array}$$

- Estimate answers before they begin, to catch any gross errors in subtraction. For example, in this problem, 597 is about 600 and 308 is about 300. Thus, the answer should be about 300.

$$\begin{array}{r} 597 \\ -308 \\ \hline \end{array}$$

Multiplication of whole numbers. The most frequent problems in multiplication are in carrying—remembering which number is carried and what to do with it when multiplying the next set of numbers. Below are some typical errors made in multiplication problems.

- **Not carrying**—In this problem, the student multiplied 3×5 and got 15. Instead of writing the 5 and carrying the 1, the student wrote 15. The same mistake was made when multiplying 2×5.

$$\begin{array}{r} 65 \\ \times\ 23 \\ \hline 1815 \\ 1210 \\ \hline 13{,}915 \end{array}$$

- **Adding the carried number before multiplying**—The student correctly multiplied 3 × 5 (15), wrote the 5, and carried the 1. However, instead of first multiplying 3 × 6 (18) and then adding the carried number (18 + 1 = 19), the student added the carried number first (6 + 1 = 7), then multiplied (3 × 7 = 21). The same mistake was made when multiplying 2 × 65.

$$\begin{array}{r} {}^{1}65 \\ \times\ 23 \\ \hline 215 \\ 140 \\ \hline 1615 \end{array}$$

- **Multiplying the carried number instead of adding it**—This student correctly multiplied 3 × 5 (15), wrote the 5, and carried the 1. However, the student then multiplied the carried number (3 × 1 = 3) before multiplying 3 × 6 (18). The same mistake was made in multiplying 2 × 65.

$$\begin{array}{r} {}^{1}65 \\ \times\ 23 \\ \hline 1835 \\ 1220 \\ \hline 13{,}035 \end{array}$$

- **Forgetting which number was carried**—In this problem, the student correctly multiplied 3 × 5 (15), wrote the 5, and carried the 1. But in the next step, the student reversed numbers and multiplied the carried number first (3 × 1 = 3) and then added the 6 to get 9, instead of calculating correctly: 3 × 6 = 18 + 1 = 19. The same mistake was made in multiplying 2 × 65.

$$\begin{array}{r} {}^{1}65 \\ \times\ 23 \\ \hline 95 \\ 80 \\ \hline 895 \end{array}$$

- **Forgetting to indent the second set of numbers in the product**—This student did all the multiplications correctly. However, instead of beginning the second product under the 2 in the number 23, the student aligned it with the 3. This gives the wrong place values to the second product and a very wrong answer of 325 instead of the correct 1495.

$$\begin{array}{r} 65 \\ \times\ 23 \\ \hline 195 \\ 130 \\ \hline 325 \end{array}$$

Again, reviewing place values and the procedures for carrying numbers may be helpful to your students. They should be encouraged to do the following:

- Write carried numbers above the next column.
- Check answers by reversing the problem and multiplying again.

For multiplying mentally, it may be helpful for students to separate the factors into combinations that are easier to work with or to multiply by rounded off numbers and then to adjust the answer. Sample 12 illustrates these two processes.

Division of whole numbers. In division, students make more varied mistakes because division also involves multiplication and subtraction. Any difficulty that students are having with these other math operations will also show up in division. The following are examples of some typical errors in division problems.

- **Not keeping numbers in correct places**—In this problem, the student placed the 6 incorrectly above the 4 of the dividend instead of above the 0. This caused the student to enter an extra 0 in the quotient, and it appears that 40 ÷ 6 = 60.

$$\begin{array}{r} 607 \\ 6\overline{)406} \\ -36 \\ \hline 46 \\ -42 \\ \hline 4 \end{array}$$

SAMPLE 12

SPLITTING FACTORS AND ROUNDING FACTORS

Splitting Factors

$12 \times 48 = \underbrace{10 \times 48}_{480}$ plus $\underbrace{2 \times 48}_{96}$

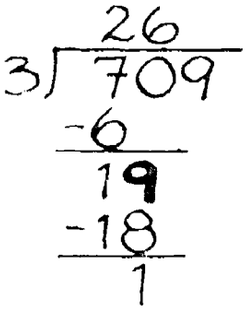
$480 + 96 = 576$

Rounding Factors

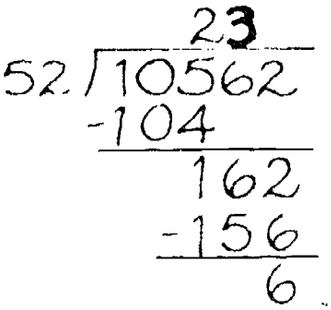
$12 \times 48 = \underbrace{12 \times 50}_{600}$ minus $\underbrace{12 \times 2}_{24}$

$600 - 24 = 576$

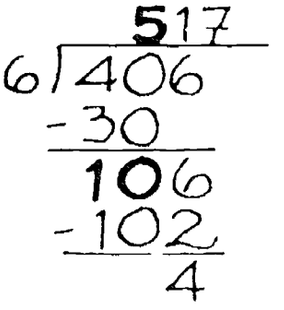
- **Failing to bring down a zero to maintain place values**—After correctly dividing (7 3 2, with a remainder of 1), the student should have brought down the 0 and divided 3 into 10. By overlooking the 0 and bringing down the 9, the student lost the place value represented by the 0.



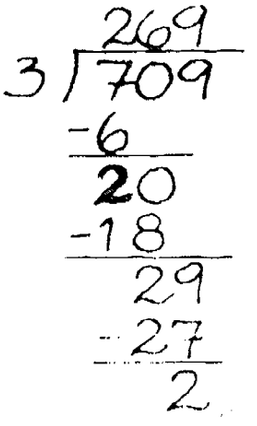
- **Failing to place a zero in the quotient**—This student correctly divided (105 52 2, with a remainder of 1) and brought down the 6. At that point, he she should have tried to divide 16 by 52 and entered a 0 above the 6, then brought down the 2. By neglecting the zero, the student gave the final 3 in the quotient the wrong place value.



- **Choosing the wrong quotient**—The student incorrectly divided (40 6 5), leaving a remainder larger than the divisor. From there, the solution went from bad to worse. The student divided 106 by 6 (17) and wrote this two-digit number in the quotient.



- **Subtracting incorrectly**—In this problem, the student incorrectly subtracted (7 6 2). This type of error can be easily missed by students, because it may not interfere with completing the rest of the problem.



- **Multiplying incorrectly**—The student incorrectly multiplied in this problem ($6 \times 6 = 38$). As with subtraction errors, this type of mistake often goes undetected if the student is able to continue with the problem.

$$\begin{array}{r} 64 \\ 6\overline{)406} \\ -38 \\ \hline 26 \\ -24 \\ \hline 2 \end{array}$$

- **Not recognizing too large a remainder**—Here the student chose the wrong quotient when dividing 46 by 6, leaving a remainder larger than the divisor.

$$\begin{array}{r} 66 \\ 6\overline{)406} \\ -36 \\ \hline 46 \\ -36 \\ \hline 10 \end{array}$$

A review of place values and careful demonstration and explanation of the division process may be helpful to your students. They should also be encouraged to do the following:

- Check all remainders against the divisor to be sure a high-enough quotient was used.
- Check subtractions and multiplications.
- Check final answers by multiplying the quotient by the divisor, then adding the remainder to get the dividend.

Addition and subtraction of fractions and mixed numbers. Difficulty with adding and subtracting fractions and mixed numbers often has to do with denominators (e.g., converting to fractions with common denominators and converting to improper fractions). Students who have trouble with multiplication are also apt to run into trouble when converting fractions. The following are some typical errors.

- **Not converting to fractions with common denominators before computing**—In this problem, the student tried to subtract fractions with different denominators. This then led the student to subtract the denominators.

$$\frac{7}{8} - \frac{3}{5} = \frac{4}{3}$$

- **Not leaving denominators constant when computing**—Here the student added the denominators, getting an answer of $^7/_{16}$ instead of $^7/_8$.

$$\frac{5}{8} + \frac{2}{8} = \frac{7}{16}$$

- **Computing new numerators incorrectly**—In converting $2^2/_5$ to an improper fraction, the student did not add in the old numerator (2). The student should have computed as follows to find the new numerator: $5 \times 2 = 10 + 2 = 12$.

$$2\frac{2}{5} + \frac{3}{5} =$$

$$\frac{10}{5} + \frac{3}{5} =$$

- **Not converting mixed numbers to improper fractions before computing**—In this problem, the student converted the fractions within the mixed numbers to fractions with common denominators ($^2/_3 = {}^8/_{12}$ and $^5/_6 = {}^{10}/_{12}$). But because the problem still contains mixed numbers, the student will probably get into trouble when trying to subtract $^8/_{12} - {}^{10}/_{12}$.

$$4\frac{2}{3} - 1\frac{5}{6} =$$

$$4\frac{8}{12} - 1\frac{10}{12} =$$

- **Not reducing final answers to proper fractions or mixed numbers**—To complete this problem, the student should have reduced $^{47}/_{6}$ to a mixed number: $7^{5}/_{6}$.

$$3\frac{1}{3} + 4\frac{1}{2} =$$

$$\frac{10}{3} + \frac{9}{2} =$$

$$\frac{20}{6} + \frac{27}{6} = \frac{47}{6}$$

- **Multiplying incorrectly**—Lack of skill in multiplication got this student into trouble when converting $^{9}/_{2}$ to a fraction with a denominator of 6. The student incorrectly multiplied $3 \times 9 = 18$, getting the wrong numerator.

$$3\frac{1}{3} + 4\frac{1}{2} =$$

$$\frac{10}{3} + \frac{9}{2} =$$

$$\frac{20}{6} + \frac{18}{6} = \frac{38}{6} - 6\frac{1}{3}$$

For most fraction difficulties, it will be helpful to review comparative sizes of fractions. Students need to have an idea of the relative sizes of common fractions: that $^{1}/_{2}$ is larger than $^{1}/_{3}$; that $^{3}/_{8}$ is larger than $^{1}/_{4}$; and so on. You can demonstrate these relationships using charts, circle graphs, other visual aids, or objects pertinent to your occupational specialty.

Depending on the area of difficulty, you may wish to review such concepts and procedures as the following:

- Basic concepts and procedures related to denominators (the number of parts into which you are splitting the whole)
- Converting to common denominators
- Converting to improper fractions
- Reducing fractions
- The rule that the value of a fraction remains the same if both numbers are multiplied by the same number

It is usually helpful to begin with problems that have like denominators and then to proceed to problems with different denominators after the first type has been mastered.

Multiplication of fractions and mixed numbers. Multiplying fractions is a simple process if the student knows the multiplication tables. Aside from errors caused by lack of skill in multiplication, most errors relate to conversion of mixed numbers and improper fractions. Difficulties with division will show up when converting answers to proper fractions. The following are some typical mistakes.

- **Multiplying incorrectly**—In this problem, the student incorrectly multiplied ($4 \times 8 = 36$).

$$\frac{3}{4} \times \frac{7}{8} = \frac{21}{36}$$

- **Not converting mixed numbers to improper fractions before computing**—Here the student should have converted $1^{7}/_{8}$ to $^{15}/_{8}$ before multiplying. Instead, the student multiplied the fractions and simply transferred the whole number to the answer.

$$1\frac{7}{8} \times \frac{5}{6} - 1\frac{35}{48}$$

- **Not reducing final answers to proper fractions**—In this problem, the final answer should have been reduced to $1^{9}/_{16}$.

$$1\frac{7}{8} \times \frac{5}{6} =$$

$$\frac{15}{8} \times \frac{5}{6} = \frac{75}{48}$$

Aside from working on multiplication tables and division procedures as needed, students may need to review a few principles of working with fractions:

- In multiplying fractions, multiply both the numerators and the denominators.
- To convert a mixed number to an improper fraction, multiply the whole number by the denominator, and add the old numerator to find the new numerator.
- To reduce an improper fraction, divide the numerator by the denominator.

Division of fractions and mixed numbers. Student division mistakes are often caused by simple multiplication errors or failure to first invert the divisor. The following are examples.

- **Not inverting before multiplying**—In this problem, the student forgot to invert ⅔.

$$\frac{3}{4} \div \frac{2}{5} = \frac{6}{20}$$

- **Multiplying incorrectly**—Here the student inverted the divisor but then multiplied incorrectly (3 × 5 = 18).

$$\frac{3}{4} \div \frac{2}{5} =$$

$$\frac{3}{4} \times \frac{5}{2} = \frac{18}{8} = 2\frac{2}{8} = 2\frac{1}{4}$$

Reviewing the need to invert the divisor and the processes for multiplying fractions may be helpful to your students. Again, working on multiplication tables may be important for some students.

Addition and subtraction of decimals. Any student who works with money or financial records needs to be able to work with decimals (also called decimal fractions). Aside from ordinary addition and subtraction procedures, most difficulties with decimals relate to placement of the decimal point and to dealing with zeros. Below are typical errors in decimal problems.

- **Failing to line up decimal points**—By aligning the decimals incorrectly, the student gave 17 a value of only .17 and 4.5 a value of only .45.

$$\begin{array}{r} 3.20 \\ 17. \\ +\ 4.5 \\ \hline 3.82 \end{array}$$

- **Failing to extend numbers with zeros in subtraction problems**—In this problem, the student should have extended 4. to 4.00. This would have made it possible to borrow and then to subtract 6 from 10, 1 from 9, and 3 from 3—for a correct answer of .84.

$$\begin{array}{r} 4. \\ -3.16 \\ \hline 1.16 \end{array}$$

- **Adding or subtracting incorrectly**—Here the student subtracted (7 − 2 = 5) instead of adding (7 + 2 = 9).

$$\begin{array}{r} 6.27 \\ +\ .32 \\ \hline 6.55 \end{array}$$

When having trouble in this area, students need to remember the following:

- A whole number has a decimal point after it.
- All decimal points must be lined up in both addition and subtraction problems.
- In the answer, the decimal point is placed directly beneath the decimal points in the problem.

Multiplication of decimals. Again, the main problem (other than not knowing the multiplication tables) is placing the decimal point in the answer. Following are typical errors in multiplying decimals.

- **Failing to count decimal places in answers**—In this problem, the student multiplied correctly but placed the decimal point in the answer below the decimal point in the multiplier. He/she should have counted the decimal places in both the multiplier and the multiplicand (three places) and placed the decimal point to the left of the 4 in the answer.

$$\begin{array}{r} 4.13 \\ \times\ 5.2 \\ \hline 826 \\ 2065 \\ \hline 2147.6 \end{array}$$

- **Multiplying incorrectly**—Here the student forgot to carry when multiplying 5 by 4.13.

$$\begin{array}{r} 4.13 \\ \times\ 5.2 \\ \hline 826 \\ 2055 \\ \hline 21.376 \end{array}$$

Aside from working on the multiplication tables, students need to remember to count the total number of decimal places in the two factors and then to count the same number of places in the answer to locate the decimal point correctly.

Division of decimals. The major stumbling blocks in the division of decimals are difficulty with division of whole numbers and placement of the decimal point. The following are two typical errors that students tend to make:

- **Not moving decimal points**—In this problem, the student failed to make the divisor (.15) a whole number (15) by moving the decimal point two places to the right and also failed to make that same change in the dividend (30.37). If done correctly, the problem would have been stated and solved as follows: 3037 ÷ 15 = 202 (remainder 7).

$$\begin{array}{r} 2.02 \\ .15\overline{)30.37} \\ -30 \\ \hline 37 \\ -30 \\ \hline 7 \end{array}$$

- **Not placing the decimal point in the quotient**—Here the student correctly moved the decimal points in the divisor and dividend. But he/she failed to place a decimal point in the quotient. The correct answer would be 27.8, not 278.

$$\begin{array}{r} 278 \\ .2\overline{)5.56} \\ -4 \\ \hline 15 \\ -14 \\ \hline 16 \\ -16 \\ \hline \end{array}$$

Students need to remember the following basic rules of dividing decimals:

- Move the decimal point in the divisor all the way to the right to make it a whole number.
- Move the decimal point in the dividend the same number of places.
- Place the decimal point in the quotient directly above the decimal point in the dividend.

It may also be helpful to explain that movement of the decimal points in the divisor and dividend represents multiplying them both by the same number (e.g., by 10 or by 100). If students are having trouble with division, multiplication, or subtraction in working the problem, they probably need to work on the tables.

Computation is not the only area of math that gives students trouble. They may also have problems in the other basic math skills—measurement, estimation, equivalents, problem solving, and so on. The following are strategies for helping students who need to improve their skills in these areas.

Measurement, estimation, and equivalents. As a vocational-technical teacher, you have an advantage in teaching measurement and estimation skills and comprehension of equivalents. These skills are best taught in relation to their practical uses on the job. The specific measuring devices used and the ways they are used will depend on the occupational area.

Measurement usually requires other fundamental skills as well, such as reading and writing numbers, counting, ordering numbers, and working with fractions.

An understanding of equivalents is also involved in many measuring tasks. For example, a person in the construction trades will need to measure in feet, inches, and fractions of inches and to understand such equivalents as 12 inches = 1 foot.

A person in commercial foods will have to measure ingredients by teaspoons, tablespoons, cups, and fractions thereof, and in metric quantities (e.g., grams and liters). He or she also needs to understand how one measuring unit relates to another. In fact, in many occupations, workers are increasingly converting to the metric system. Students who leave your program familiar with metric equivalents will be much better prepared for future trends in their occupations.

Using actual on-the-job applications may be an effective way of improving students' skills, not only in measurement and comprehension of equivalents, but also in the underlying computation skills. What better way is there to learn fractions, for example, than by manipulating them in taking accurate measurements?

Some students may find it helpful to **memorize** the equivalents most commonly used in their particular occupational area. Doing so reduces the amount of computation they will need to do in the future and makes it easier to do mental figuring.

For example, a student in a textiles program should know the decimal equivalents of ⅛, ⅜, ⅝, ⅞, ¼, ½, and ¾ in order to figure yardage costs more easily. The following are examples of how fraction and decimal equivalents can be interchanged for easy mental calculation. Notice that the technique of splitting factors, shown in sample 12, is used in both these examples.

24 yards at $2.50 =	3¾ yards at $2.00 =
24 yards at 2½ =	3.75 × 2 =
24 × 2 = 48	3 × 2 = 6.00
24 × ½ = 12	.75 × 2 = 1.50
48 + 12 = $60	6.00 + 1.50 = $7.50

A helpful rule of thumb for students to remember in converting from one measurement unit to another is this: *multiply* to get more units of a smaller measure; *divide* to get fewer units of a larger measure.

Estimation is a skill that comes primarily from **practice.** You can devise a variety of games and exercises relevant to your vocational-technical area that will give students practice in estimating. For example, you might line up several containers and ask students to estimate how many ounces each will hold. Then you could have them actually pour water into them to check their accuracy. The same kind of activity could be done using board lengths, number of feet or yards from one point to another, and so on.

For estimating answers to computation problems, students should be encouraged to round off numbers for rapid estimation. They may also find it helpful to establish points of reference. For example, they know how big a half gallon of milk is. Is this other container larger or smaller? Or, they know that this student's height is about 6 feet. How much higher is the wall?

Problem solving. Problem solving is essentially the application of judgment and computation skills to obtain needed information. Part of the ability to solve problems is simply knowing that you can.

As with measurement, problem solving is best taught in relation to real, on-the-job problems. The kinds of problems your students will be called upon to solve will depend entirely on their vocational-technical area and occupational goals. You can help them improve their problem-solving skills by presenting such problems in a real context—not as written problems with all the facts neatly laid out for them.

One approach is to begin by reviewing the problem-solving questions:

- What do I need to find out?
- What do I already know that can help me find the answer?
- What more do I need to know in order to find the answer?
- How can I use what I already know to find out more?
- What is the solution?

You might then walk students through the steps of solving some sample problems by asking them the key questions and letting them provide the answers. As students gain confidence, they should become increasingly able to ask and answer the questions themselves. Eventually, they should become better able to recognize problems as they naturally occur, to intuitively sort out useful information, and to find the answers they need.

Organization of data. Students need to be able to set up, read, and draw conclusions from numerical data in the form of charts, tables, graphs, or other graphic displays. They should realize that numerical data compiled in these forms can actually be a shortcut for them—especially if they have reading problems—because a lot of extra language is eliminated.

Being able to use numerical data in these forms is partly attitudinal. That is, your students need to be confident that they can understand the data forms if they use a logical approach. You can help your students improve their skills with organized data by presenting some of the data forms they will encounter in their work and showing them how to read the forms.

For example, paycheck stubs, time cards, schedules, stock records, size charts, equivalent charts, drill-speed charts, and other job-related data forms could be reviewed with the students as they come up in your lessons.[5]

Another way for students to become comfortable with displayed data is to construct data displays themselves. You might have them collect, organize, and present data for class projects and then present and explain the data to the rest of the class. The following are examples of such projects:

- Developing pay scale charts
- Extracting employment data from various sources and presenting the information in tabular form
- Constructing bar graphs or circle charts to depict such relationships as percentages of time spent on different work activities

Algebra. For most students, algebra appears difficult largely because it looks different—rather like a foreign language. Students need to understand that algebra is like shorthand, with letters used to represent numbers and special symbols used to indicate the kinds of computation to be done.

Algebra is a convenient way to express complex relationships between numbers and is used to solve problems with unknowns. In fact, it may be helpful to work on algebra and problem-solving skills at the same time so that students understand the practical uses of algebra in on-the-job problem-solving situations.

It may also be helpful to review with your students the basic rules and symbols used in algebra, such as the following:

Basic Rules

- Order is the key to solving algebraic problems. Do operations in brackets [ ] and parentheses ( ) first.
- Do multiplication and division from left to right.
- Do addition and subtraction from left to right.

Symbols

plus	+
minus	−
multiply	•, ( ), or juxtaposition of symbols (e.g., ab)
divided by	÷ or bar (e.g., $\frac{a}{b}$)

You may find it helpful to refer to a basic algebra textbook to obtain a thorough outline of algebraic rules and symbols.

Geometry. The amount of geometry that students need to master will vary greatly from one trade to another. For example, some health occupations might involve little or no geometry. Carpentry students might focus primarily on plane geometry or on formulas for finding area and dimensions of flat surfaces. Sheet metal students would use solid geometry as well, to find the area and volume of cylinders, cones, and other three-dimensional shapes and areas.

In helping your students to improve their skills in geometry, you will need to concentrate on the ways geometry is actually used on the job. It would therefore be helpful to review and apply geometric principles and formulas as they naturally come up in the course content.

For example, students in machine shop would need to use the formula for finding the circumference of a circle when figuring cutting speeds. Students in construction trades would need to use formulas for finding the area of rectangles and triangles when figuring the amount of materials needed to cover a given surface.

Students may also find it helpful to construct actual geometric shapes out of paper or other materials while learning related formulas.

5. To gain skill in assisting students in reading graphic displays, you may wish to refer to Module M-2, *Assist Students in Developing Technical Reading Skills.*

Provide Practice Activities

No matter how well the mathematical theories are explained and specific trouble spots are corrected, your students will need plenty of practice to improve their math skills significantly. Practice, however, does not have to consist of page after page of problems. There are a variety of ways in which you can provide practice in specific math skills within your usual curriculum.

Class Assignments and Projects

Among the most important avenues for practice are the assignments and projects that are a natural part of your program. You can set up these activities to include the math skills in which your students need practice. This can be done on an individualized basis so that each student's work requires the types of math in which he or she needs to improve.

For example, imagine that building trades students are working on blueprints. For a student who needs practice on working with fractions, the instructor could assign scale and dimensions in a way that would emphasize computation with fractions. On the same activities, the instructor might have another student work with decimals to provide practice in that skill.

Similarly, if dietetics students are learning to plan supply orders on the basis of a week's menus, the instructor could arrange individual assignments to emphasize computation with whole numbers, fractions, decimals, percentages, or whatever skills the students need to practice.

Math Exercises

If you have taught your students mathematical shortcuts and tricks to help them improve specific math skills, you can provide practice exercises to enable students to gain skill in their use. For example, you might provide exercises, drills, or even contests (for speed and accuracy) in which students do such tasks as the following:

- Add by grouping numbers
- Estimate by rounding off numbers
- Compute by converting first to an easier form (e.g., fractions to decimals)
- Compute by using number lines or charts

In order to make math more fun and familiar to students, it is important that any such exercises be presented in a positive atmosphere. Activities should be designed to encourage students to increase their accuracy and their speed, while also breaking down some of the attitudinal barriers that students may have built concerning math.

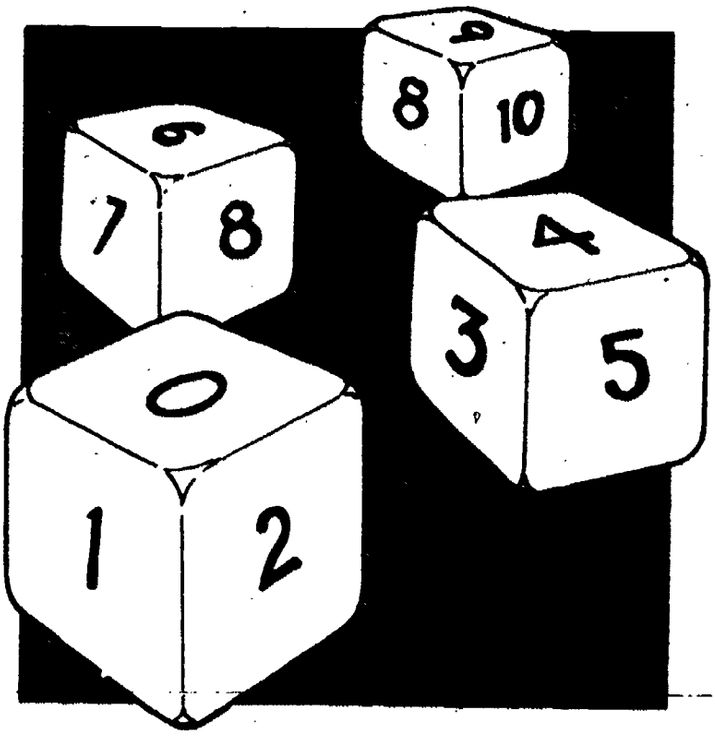
A math specialist may be able to help you develop math exercises, appropriate to your program, that focus on specific skills needed by your students.

Games

Math games, if carefully chosen or constructed and correctly integrated into the program, can be an effective and enjoyable way to practice math skills. They should be designed to provide practice in the specific skills that students are trying to improve, and they should be used to provide practice at the right time—when working on those skills.

Games of chance, for example, can be constructed to provide practice in probability and problem solving, as well as computation. For example, in one such game, students have four cubes or dice: two have the numbers 0 through 5; two have the numbers 5 through 10.

By rolling the cubes one at a time, the students try to roll as close to a total of 15 as possible. Each student may roll as many of the cubes as he/she wishes, may roll each cube only once, and may stop at any time. While providing practice in addition and subtraction, the game also challenges students to consider the probability of improving scores by selecting different cubes to roll.[6]



6. Described in Stephen S. Willoughby, *Teaching Mathematics: What Is Basic?* (Washington, DC: Council for Basic Education, 1981), pp. 27–28.

You can invent other types of games, such as the following, to provide practice in specific math skills:

- Contests of speed in the various computation skills
- Guessing games (guessing the volume of containers, length of distances, and so on)
- Brainteasers (these can be given out at the end of a class and reviewed at the beginning of the next)

Some commercial games provide excellent practice in specific math skills. For example, such games as Yahtzee, backgammon, bridge, Monopoly, Tripoly, Uno, and Oh-No_99 all require some math. You may feel that such games are not an appropriate use of class time, especially since the relationship of game playing to learning often appears remote. However, your situation might permit student use of such games during lunch, scheduled breaks, free periods, or even as an incentive or reward at certain times.

Simulations

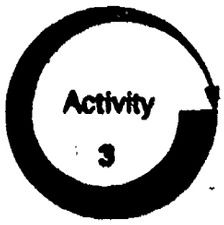
Simulations are another way to give students practice in specific math skills, while also developing occupational skills and career awareness. Although creating a simulation requires a good deal of preparation time, simulations have several advantages:

- They can be used repeatedly, often with different results.
- They can be designed specifically to enhance your vocational-technical program.
- They can be developed in such a way that they do not appear childish to the students.
- They can be adapted to meet individual student needs.
- Roles can be designed to emphasize specific math skills.

Developing a simulation calls for identifying occupations related to your vocational-technical area and developing a role, or a task to be accomplished, for each occupation. Usually simulation roles depend on interaction among or between role-players. You can set up each role with facts, figures, and task instructions that require the use of specific math skills.[7]

7. To gain skill in using simulations, you may wish to refer to Module C-5, *Employ Simulation Techniques*.

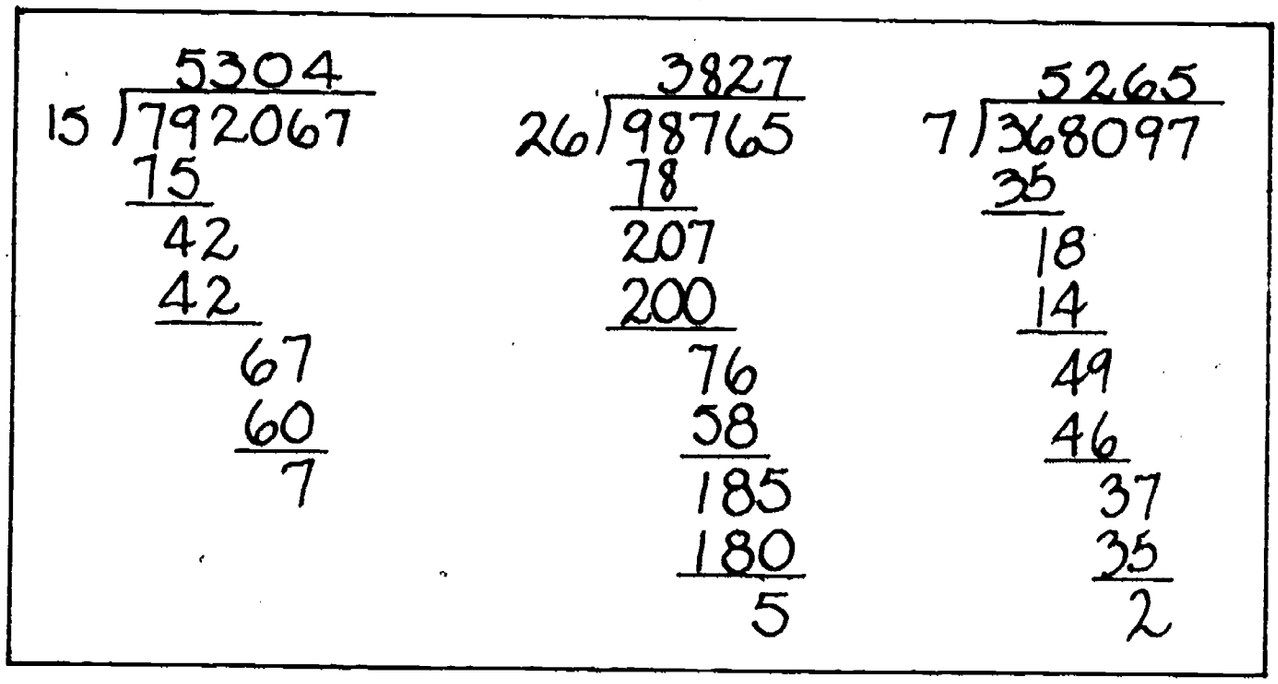
To increase your awareness of available techniques and materials for improving specific math skills, you may wish to review student and teacher materials such as those produced by the Interstate Distributive Education Curriculum Consortium (IDECC). These materials include learning activity packages for specific math skills, such as "Addition and Subtraction," "Multiplication and Division," and "Fractions and Percents."



The following case situations describe four students who need to improve specific math skills. Read each case situation and the question following it. Using the question as a guide, explain in writing how you would help the student improve his/her math skills.

CASE SITUATIONS

1. Carolyn Mehaffie, a student in your program, has turned in a worksheet with the following problems on it.



What math skills do you think Carolyn is having trouble with, and how would you help her improve those skills?

2. Al Frizell has come to you saying that he can't complete a class project because the dimensions don't come out right. When he explains how he came up with his figures, you find that Al is having trouble adding and subtracting fractions.

   How would you go about helping Al improve his skills in working with fractions?

3. Elijah Moore has been working on completing order forms, using self-evaluation checks to monitor his own progress as he works through the unit. Elijah has come to you because his final cost figures are often wrong and he doesn't know why. Looking over his orders, you find that he is able to compute with whole numbers fairly well but that he does not understand placement of decimal points in decimal computations.

   How would you help Elijah improve his skills with decimals?

4. You have assigned a project requiring your students to (1) figure how much material they will need to make an item of a given size, (2) obtain the materials, and (3) complete the project. Most of your students have begun the construction phase of the project, but three students are still trying to figure out how much material they will need. They simply don't know how to solve the problem.

   How would you help these students improve their problem-solving skills?

Compare your written responses to the case situations with the model responses given below. Your responses need not exactly duplicate the model responses; however, you should have covered the same major points.

MODEL RESPONSES

1. Carolyn seems to have two areas of difficulty. The first and most serious is that she has not mastered the multiplication tables—as indicated by such errors as $3 \times 15 = 42$, $8 \times 26 = 200$, $2 \times 26 = 58$, $7 \times 26 = 180$, and $6 \times 7 = 46$.

   The second problem is that, while she appears to have a fairly good command of the division process, she is neglecting to bring down zeros to maintain place values.

   There are several possible strategies for helping Carolyn to improve her multiplication skills. First, she should be encouraged to memorize the multiplication tables, perhaps beginning with some of the easier ones, like 2s and 5s.

   Various shortcuts and aids can also be used, not only to help Carolyn learn the tables, but also to enable her to do the rest of the math required for her program until she knows the tables. For example, you could provide a multiplication chart for reference.

   Frequent use of such a chart could help Carolyn "absorb" some of the number combinations almost unconsciously. A program of charted timings could also help her to commit the multiplication tables to memory.

   It may help Carolyn to know hints and rules of thumb for multiplication—for example, that reversing the factors does not change the answer ($7 \times 5 = 5 \times 7$). If she becomes stronger in some tables (e.g., 5s) than in others, she can be encouraged to use this to her advantage.

   For example, instead of multiplying 6×8, she could mentally multiply 5×8 (40) and add 8 (48). Perhaps rounding multipliers or splitting factors would be useful techniques for Carolyn.

   Carolyn should have plenty of opportunity for practicing multiplication as she gains skill. You might plan her regular assignments to emphasize multiplication skills.

   Finally, if Carolyn's difficulty persists despite your efforts and hers, you might consider whether using a calculator would be consistent with the job requirements related to her occupational goals.

   Improvement will probably be easier to achieve in the matter of bringing down zeros. It may suffice to remind Carolyn that zeros must be brought down to maintain place values in the answer. Reviewing the concept of place values may help her to remember the important function of zeros.

2. To help Al, you need to know more about where he is going wrong. A first step might be to break the math skills (adding and subtracting fractions) into subtasks and then to watch as Al works some sample problems.

   With subtasks in mind, you should be able to determine whether Al's difficulty stems from, for example, not converting to fractions with common denominators, not leaving denominators constant when computing, computing new numerators incorrectly, or other specific errors. When you have defined the specific problem area, you will be able to work directly on that area.

   If the main problem is in following the correct process to compute the answer, you should explain and demonstrate the process of adding or subtracting fractions and review the basic rules. In selecting practice problems for Al, you may wish to give him problems with like denominators first. After he masters those, he could move on to more complex ones.

   If Al's difficulty stems from a lack of conceptual understanding of fractions, other strategies may be appropriate. Visual aids (e.g., pie charts or diagrams) and tangible objects may be useful as you explain fractions. Activities in which Al manipulates objects may be appropriate.

   As Al gains skill in adding and subtracting fractions, he will need practice activities to reinforce his new skills. Class assignments emphasizing these skills, drills, computation contests with other students, games, or simulations are possible ways to provide practice, depending on your vocational-technical program.

3. Having discovered his problem through self-evaluation is an advantage for Elijah. He has determined for himself that he needs to improve his math skills. This sense of responsibility may give him the motivation it takes to bring about the improvement.

   Elijah may need to review the basic rules of working with decimals (e.g., line up decimal points in addition and subtraction, count decimals in a multiplication problem to locate the decimal point in the answer). He may also need to review the concept of place values in relation to decimals.

   In explaining concepts and rules, it may be helpful for you to demonstrate the ideas using visuals (e.g., charts or pictures) or tangible objects—perhaps play money.

   When Elijah understands these concepts, he is likely to find applications of the concepts most relevant if they relate to the order forms he was originally working on. You might have him rework the order forms and repeat the self-checks to observe his own progress. Seeing the achievement that results from his own efforts may further motivate him to continue working on his math skills.

   Practice activities will help Elijah to solidify the improvement in his math skills. Class assignments can be designed to emphasize decimal computations. If necessary, other activities, such as games or math exercises, can be provided to give additional practice.

4. These students need to learn a rational approach to finding solutions to practical problems. Learning a set of problem-solving questions that can be applied to any problem can give them both a method of seeking solutions and the confidence that they can dissect a problem and use the information they have to find other information.

   One approach to helping these students is to ask them questions that will help them identify and examine the problem. For example:

   - What do you need to find out?
   - What do you already know that can help you find the answer?
   - What more do you need to know in order to find the answer?
   - How can you use what you already know to find out more?
   - What is the solution?

   As they answer each question, you can help them to organize their information so that it leads to a solution.

   When the students have solved the problem, you can pose similar problems to which the students need to apply the problem-solving process. You should encourage them to become increasingly responsible for defining the problem, asking the right questions, and organizing their information so that it leads to a solution.

   To provide additional practice in problem solving, you need to look for ways to incorporate problem solving into other assignments. For example, you may want to avoid supplying too much information when you assign projects and other class activities. Instead, you might require the students to use a few given facts and figures to generate enough other information to complete the assignment.

Level of Performance: Your written responses to the case situations should have covered the same **major** points as the model responses. If you missed some points or have questions about any additional points you made, review the material in the information sheet, Improving Specific Math Skills, pp. 24–46, or check with your resource person if necessary.

Learning Experience III

OVERVIEW

The following case study describes how a vocational teacher assisted students in improving their math skills. Read the case study and then critique in writing the teacher's performance, explaining (1) the strengths of the teacher's approach, (2) the weaknesses of the teacher's approach, and (3) how the teacher should have assisted the students in improving their math skills.

CASE STUDY

Mr. Rawlings, a vocational teacher, had just gotten a new group of students in his program. Well aware from past experience that new students don't always have the needed skill levels in the 3 Rs, he decided to assess their skills early so that he would be able to accommodate their needs throughout the program.

For the math skills, Mr. Rawlings went to the math teacher and got several comprehensive math tests. Looking them over, he chose one that included all areas of computation, some algebra and geometry, and many word problems to test problem-solving ability. "This one looks like it covers at least as much math as we'll ever use in my classes," he said to himself. "Better to be thorough and find out just where the students stand."

When Mr. Rawlings gave the test, he was careful to explain to the students (1) why they were taking the test, (2) that they wouldn't get a grade for it, (3) how much time they would have, and (4) how the test was set up. He reviewed the vocabulary used in the directions and encouraged the students to ask questions any time they needed to.

After the test, he told the students that their scores would be available on Monday and that they could come to him if they were interested.

When he scored the tests, Mr. Rawlings found that many students had trouble with multiplication, long division, fractions, decimals, percents, and solving word problems. "Wow—this is going to be some challenge!" he thought as he planned how he would help his students improve their math skills while they pursued their occupational goals.

Since so many students were having trouble, he decided to begin with a topic that would interest everyone and give students a chance to work on several math skills at once: earnings.

Introducing the unit on earnings, Mr. Rawlings informed the students that their math scores had been fairly low and that they needed to work on several areas, which he listed on the board. He explained how important these skills are for a worker, not only for completing their job duties, but for computing wages and benefits, understanding their earnings statements and paychecks, and planning a budget.

Aware of how important it is to be positive and encouraging, Mr. Rawlings assured the students that if they tried hard they could surely improve their math skills. He noted that, although they would have weekly quizzes to check their progress, they would not actually be graded in the math portion of the course.

Because all the students needed to know about earnings and so many of them needed to improve their skills in the related math, Mr. Rawlings planned primarily large-group instruction. He explained how the earnings statement is laid out; what the different amounts are; how such deductions as taxes, Social Security, and insurance are figured; how the benefits system works; how the pay scale relates to time on the job; and so on.

The students found this really interesting, especially since it related to how much money they would be making. Mr. Rawlings brought up hobbies and other outside interests he knew his students had, which they would be better able to afford if they handled their money well.

Mr. Rawlings made sure all the students studied the math chapter in the technical-skills textbook he used in the program. This gave them all a common beginning and a reference they could use later.

Then, when students had trouble with some of the math, Mr. Rawlings tried to explain each mathematical concept simply and clearly, and he wrote the basic rules for it on the board. He demonstrated problems on the board and used large wall charts—one with the pay scale gradations and one showing a completed earnings statement—to illustrate his explanations.

To give students practice with problems related to earnings, Mr. Rawlings passed out sample earnings statements to each student and assigned problems to be completed using information from the handouts.

For students who just didn't seem to know their multiplication tables, he assigned one table at a time to be memorized—not so much that it would overwhelm them, but enough that they would have memorized them all by the end of the program.

Whenever students worked problems on the board, Mr. Rawlings watched for signs of specific difficulty. For example, when one student kept getting problems wrong because she was placing the decimal points incorrectly, he took advantage of the situation and explained place values and working with decimals to the whole class.

Then Mr. Rawlings had the student at the board work the problem properly to show her achievement. He followed up on this activity by assigning other, more difficult problems to the students. Mr. Rawlings believed in building on students' success to increase their self-confidence.

To improve the students' skill in solving word problems, Mr. Rawlings gave them sheets of practice problems, pointed out key words that indicated how to solve the problems, and led them through solving several of them. He was careful to make the problems relevant by relating them to earnings or to the vocational-technical program.

As Mr. Rawlings assigned work in other areas of the program, he tried to reinforce the students' math skills development by emphasizing the math skills they were currently working on. This gave the students plenty of practice through which they could continue to improve their math skills.

NOTES

Compare your written critique of the teacher's performance with the model critique given below. Your response need not exactly duplicate the model response; however, you should have covered the same **major** points.

MODEL CRITIQUE

Mr. Rawlings's view of math skills improvement as part of his responsibility is highly commendable. His general attitude and his many efforts to help students improve their math skills will certainly benefit them.

Unfortunately, Mr. Rawlings made a faulty beginning that would be hard to overcome later. Without assessing the specific math skills **required** for his program, he had nothing to which to compare the students' skill levels. Had he reviewed occupational analyses or competency profiles and analyzed the ways in which math is used on the job and the proficiency levels needed, Mr. Rawlings would have had a very good basis for setting realistic learning objectives for the students once their present skill levels were known.

As it was, he failed to assess not only the math requirements but the adequacy of his own skills for improving students' basic math skills. Mr. Rawlings also failed to consider whether the textbook and other instructional materials he was using covered basic math development adequately.

He should, for example, have reviewed these materials to answer questions such as the following: Do they present basic math in ways appropriate for the students' learning needs? Do they provide clear and simple explanations and enough opportunity for practice? And so on. The technique he used later (assigning a chapter from the textbook) may or may not have been a good one, depending on the adequacy of the text.

Mr. Rawlings was quite correct to assess his students' basic math skills early in the program. This would enable him to plan his instruction to meet the students' needs. However, the assessment approach he chose left something to be desired. Standardized tests, while not necessarily the best approach in this situation, can be useful—if they are short, tailored to the program, and suited to students' capabilities (e.g., reading levels).

But without knowing the exact math requirements for the occupational area, Mr. Rawlings had no way to tailor the test to the program. The test he chose was also too broad, probably too long, and attempted to assess problem-solving ability through word problems alone.

For students who have trouble with math anyway, this kind of test is apt to be altogether too threatening to give an accurate assessment of their math skills. Mr. Rawlings was somewhat sensitive to this. He did try to lessen the students' fear by explaining the purpose of the test, the directions, the vocabulary, and so on.

However, when he reviewed the scores, he had no way of knowing how much of the students' poor performance was really due to math deficiency. Many performance problems could have resulted from test fear, inadequate reading ability, or other difficulties.

At this point, however, he still could have salvaged the situation. He should have sat down with each student, gone over the test, and reviewed the student's strengths and weaknesses. He should have had the student show him how he or she worked some of the problems that were solved incorrectly.

By using that approach, Mr. Rawlings could have gotten a better idea of each student's real difficulties—whether with basic concepts or perhaps with minor steps in the mathematical operations. Each student then could have **participated** in making the decision that he or she needed to improve certain math skills. Each student could have **chosen** to commit his or her efforts to that improvement.

After a shaky beginning, Mr. Rawlings did a fairly good job of working with the students to improve their math skills. He was creative in incorporating the math into the vocational-technical content. Teaching math in an occupational context and attempting to show the relationship of math to occupational and personal interests could help motivate the students to learn.

He did try to be positive and encouraging. However, his early efforts at creating a positive atmosphere should have been sustained throughout his instruction. Singling out a student who is working a problem incorrectly at the board is inherently threatening. It can intimidate not only the student at the board but also the other students, who know they may be next if they make public" mistake.

And this was hardly a good example of building on a student's **success** to increase self-confidence. In reality, the student at the board was building on failure. When she got the problem right after additional instruction, Mr. Rawlings should have reinforced her success by giving her more problems of **equal** difficulty. Later, after her repeated success, he could have increased the difficulty of the problems he assigned.

Perhaps, Mr. Rawlings's greatest fault in working with the students was that he did not individualize instruction. In choosing only large-group instructional techniques, he ignored students' individual needs.

For example, some students might not have needed to start at the beginning with each new math skill. Perhaps a review of basic rules would have sufficed for these students. Some students might have responded better to one-to-one or small-group instruction. Perhaps others had reading problems that should have been accommodated in the choice of instructional techniques.

Undoubtedly, all the students would have benefited from a little more fun in the learning. Enjoyable activities—games, contests, brainteasers, and similar activities—might have helped to offset the large-group instruction and the grim prospect of weekly quizzes.

Other techniques besides memorization (e.g., shortcuts and number charts) might have helped students learn the multiplication tables. With a better view of how math is used on the job, Mr. Rawlings might even have determined that quick recall of multiplication tables was unnecessary and that calculators could be used.

It is true that the students—through Mr. Rawlings's patient instruction—may be better able to solve written word problems. However, their ability to solve problems on the job probably will be little affected. Problems that are encountered naturally in almost any job are not presented on paper with key words and just the right amount of information.

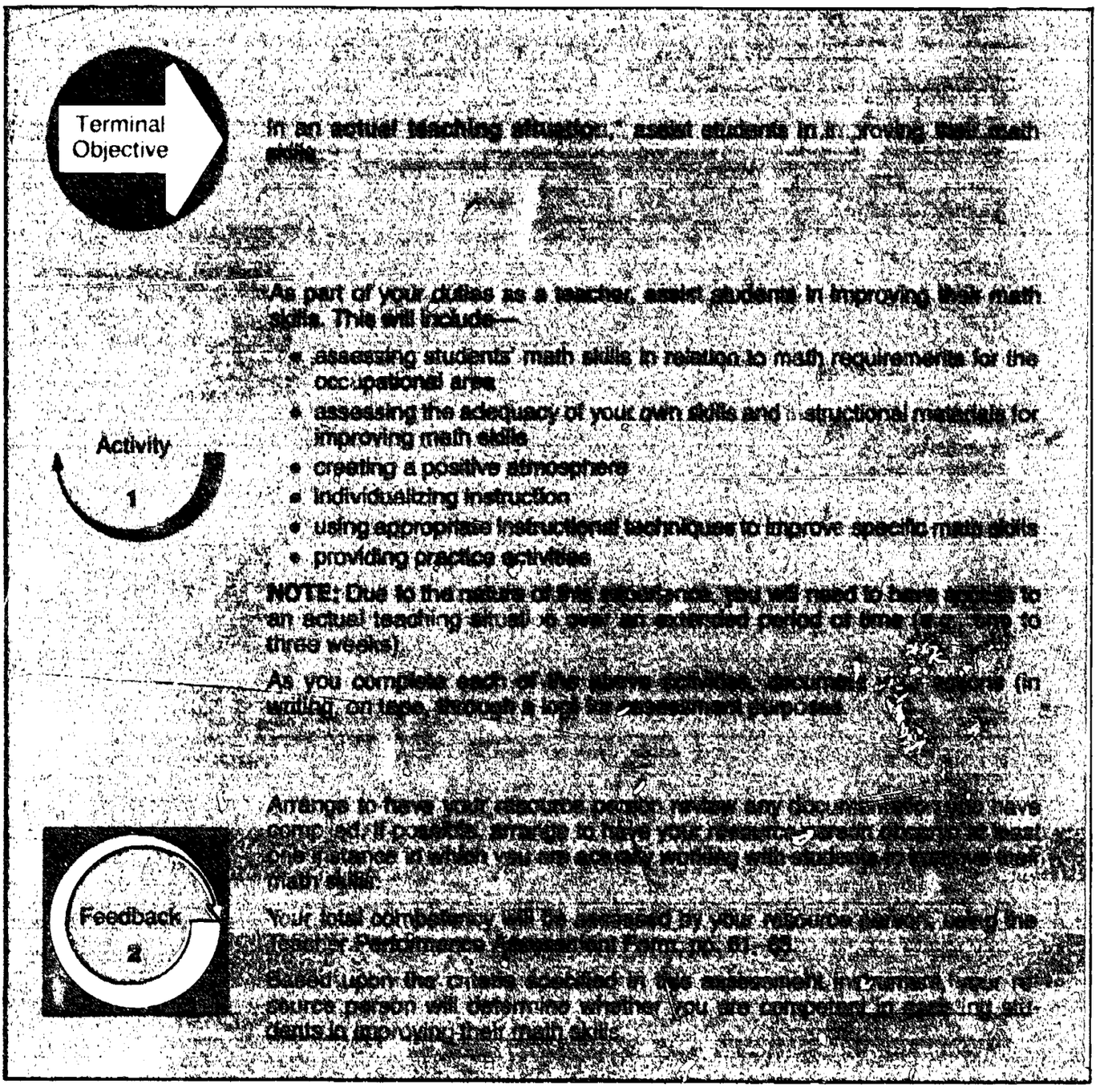
A better focus for students' efforts would have been to use the problem-solving questions to solve problems that naturally occur in the vocational-technical program: what is the problem, what information do I have, what information do I need, and how can I solve the problem?

Finally, on the positive side, reinforcing the learning of math in other class assignments and projects was an effective way to provide practice within the context of occupational development.

Level of Performance: Your written critique should have covered the same **major** points as the model critique. If you missed some points or have questions about any additional points you made, review the material in the information sheets, pp. 7–17 and 24–46, or check with your resource person if necessary.

Learning Experience IV

FINAL EXPERIENCE



*For a definition of "actual teaching situation," see the inside back cover.

NOTES

TEACHER PERFORMANCE ASSESSMENT FORM

Assist Students in Improving Their Math Skills (M-5)

Directions: Indicate the level of the teacher's accomplishment by placing an X in the appropriate box under the LEVEL OF PERFORMANCE heading. If, because of special circumstances, a performance component was not applicable, or impossible to execute, place an X in the N/A box.

Name _____

Date _____

Resource Person _____

In preparing to assist students in improving their math skills, the teacher:	LEVEL OF PERFORMANCE					
	N/A	None	Poor	Fair	Good	Excellent
1. assessed the math skills required to master the competencies for the occupational area, including:						
a. basic math competencies	☐	☐	☐	☐		
b. specific math skills	☐	☐	☐	☐		
2. assessed students' competency levels in relation to the math requirements, using the following approaches:						
a. formal and/or informal assessment techniques, as appropriate for students' individual needs	☐	☐	☐	☐		
b. realistic problem-solving activities	☐	☐	☐	☐		
c. strategies for making the situation as nonthreatening as possible	☐	☐	☐	☐		
d. opportunities for student self-evaluation	☐	☐	☐	☐		
e. reviews of assessment results with each student	☐	☐	☐	☐		
3. assessed his/her own knowledge and competency in the identified math skills, including:						
a. understanding of basic concepts	☐	☐	☐	☐		
b. ability to perform math operations	☐	☐	☐	☐		
c. ability to help students learn the concepts and operations	☐	☐	☐	☐		
4. assessed existing instructional materials to determine their adequacy for improving basic math skills	☐	☐	☐	☐		
5. adapted or supplemented instructional materials as necessary	☐	☐	☐	☐		
6. planned appropriate courses of action, including one or more of the following approaches:						
a. learning activities within the occupational program to improve specific math skills	☐	☐	☐	☐		
b. referral to a specialist for more intensive math remediation	☐	☐	☐	☐		

	N/A	None	Poor	Fair	Good	Excellent
c. supportive activities within the occupational program to complement the specialist's remedial activities	☐	☐	☐	☐		
In working with students to improve their math skills, the teacher:						
7. created a positive atmosphere by:						
a. projecting a positive attitude	☐	☐	☐	☐		
b. creating a nonthreatening environment	☐	☐	☐	☐		
c. encouraging students to take responsibility for improving their own math skills	☐	☐	☐	☐		
8. individualized instruction by:						
a. considering students' learning styles and other individual needs in planning instructional activities	☐	☐	☐	☐		
b. planning instructional activities to allow students to work on the specific math skills in which they needed improvement	☐	☐	☐	☐		
c. relating learning activities to students' occupational and personal interests	☐	☐	☐	☐		
9. used appropriate instructional techniques to help students improve specific math skills, including one or more of the following:						
a. simple, clear explanations of concepts and basic rules	☐	☐	☐	☐		
b. demonstrations of step-by-step procedures	☐	☐	☐	☐		
c. development of math skills as a part of normal program content	☐	☐	☐	☐		
d. visual aids (e.g., charts, diagrams,) and tangible objects	☐	☐	☐	☐		
e. manipulative activities	☐	☐	☐	☐		
f. work on specific problem areas as a means of building to a larger skill	☐	☐	☐	☐		
g. practical math activities, designed to help students improve their problem-solving skills	☐	☐	☐	☐		
10. provided practice activities, including one or more of the following:						
a. regular class assignments and projects, adapted to emphasize math	☐	☐	☐	☐		
b. math exercises and games, designed to improve speed and accuracy	☐	☐	☐	☐		
c. simulations	☐	☐	☐	☐		

Level of Performance: All items must receive N/A, GOOD, or EXCELLENT responses. If any item receives a NONE, POOR, or FAIR response, the teacher and resource person should meet to determine what additional activities the teacher needs to complete in order to reach competency in the weak area(s).

NOTES

ABOUT USING THE NATIONAL CENTER'S PBTE MODULES

Organization

Each module is designed to help you gain competency in a particular skill area considered important to teaching success. A module is made up of a series of learning experiences, some providing background information, some providing practice experiences, and others combining these two functions. Completing these experiences should enable you to achieve the terminal objective in the final learning experience. The final experience in each module always requires you to demonstrate the skill in an actual teaching situation when you are an intern, a student teacher, an inservice teacher, or occupational trainer.

Procedures

Modules are designed to allow you to individualize your teacher education program. You need to take only those modules covering skills that you do not already possess. Similarly, you need not complete any learning experience within a module if you already have the skill needed to complete it. Therefore, before taking any module, you should carefully review (1) the introduction, (2) the objectives listed on p. 4, (3) the overviews preceding each learning experience, and (4) the final experience. After comparing your present needs and competencies with the information you have read in these sections, you should be ready to make one of the following decisions:

- That you do not have the competencies indicated and should complete the entire module
- That you are competent in one or more of the enabling objectives leading to the final learning experience and, thus, can omit those learning experiences
- That you are already competent in this area and are ready to complete the final learning experience in order to "test out"
- That the module is inappropriate to your needs at this time

When you are ready to complete the final learning experience and have access to an actual teaching situation, make the necessary arrangements with your resource person. If you do not complete the final experience successfully, meet with your resource person and arrange to (1) repeat the experience or (2) complete (or review) previous sections of the module or other related activities suggested by your resource person before attempting to repeat the final experience

Options for recycling are also available in each of the learning experiences preceding the final experience. Any time you do not meet the minimum level of performance required to meet an objective, you and your resource person may meet to select activities to help you reach competency. This could involve (1) completing parts of the module previously skipped, (2) repeating activities, (3) reading supplementary resources or completing additional activities suggested by the resource person, (4) designing your own learning experience, or (5) completing some other activity suggested by you or your resource person.

Terminology

Actual Teaching Situation: A situation in which you are actually working with and responsible for teaching secondary or postsecondary vocational students or other occupational trainees. An intern, a student teacher, an inservice teacher, or other occupational trainer would be functioning in an actual teaching situation. If you do **not** have access to an actual teaching situation when you are taking the module, you can complete the module **up to** the final learning experience. You would then complete the final learning experience later (i.e., when you have access to an actual teaching situation).

Alternate Activity or Feedback: An item that may **substitute** for required items that, due to special circumstances, you are unable to complete.

Occupational Specialty: A specific area of preparation within a vocational service area (e.g., the service area Trade and Industrial Education includes occupational specialties such as automobile mechanics, welding, and electricity).

Optional Activity or Feedback: An item that is not required but is designed to **supplement** and enrich the required items in a learning experience.

Resource Person: The person in charge of your educational program (e.g., the professor, instructor, administrator, instructional supervisor, cooperating/supervising classroom teacher, or training supervisor who is guiding you in completing this module.

Student: The person who is receiving occupational instruction in a secondary, postsecondary, or other training program.

Vocational Service Area: A major vocational field: agricultural education, business and office education, marketing and distributive education, health occupations education, home economics education, industrial arts education, technical education, or trade and industrial education.

You or the Teacher/Instructor: The person who is completing the module.

Levels of Performance for Final Assessment

N/A: The criterion was not met because it was **not applicable** to the situation.

None: No attempt was made to meet the criterion, although it was relevant.

Poor: The teacher is unable to perform this skill or has only **very limited ability** to perform it.

Fair: The teacher is unable to perform this skill in an acceptable manner but has **some ability** to perform it.

Good: The teacher is able to perform this skill in an **effective** manner.

Excellent: The teacher is able to perform this skill in a **very effective** manner.

Titles of the National Center's Performance-Based Teacher Education Modules

Category A: Program Planning, Development, and Evaluation

- A-1 Prepare for a Community Survey
- A-2 Conduct a Community Survey
- A-3 Report the Findings of a Community Survey
- A-4 Organize an Occupational Advisory Committee
- A-5 Maintain an Occupational Advisory Committee
- A-6 Develop Program Goals and Objectives
- A-7 Conduct an Occupational Analysis
- A-8 Develop a Course of Study
- A-9 Develop Long-Range Program Plans
- A-10 Conduct a Student Follow-Up Study
- A-11 Evaluate Your Vocational Program

Category B: Instructional Planning

- B-1 Determine Needs and Interests of Students
- B-2 Develop Student Performance Objectives
- B-3 Develop a Unit of Instruction
- B-4 Develop a Lesson Plan
- B-5 Select Student Instructional Materials
- B-6 Prepare Teacher-Made Instructional Materials

Category C: Instructional Execution

- C-1 Direct Field Trips
- C-2 Conduct Group Discussions, Panel Discussions, and Symposiums
- C-3 Employ Brainstorming, Buzz Group, and Question Box Techniques
- C-4 Direct Students in Instructing Other Students
- C-5 Employ Simulation Techniques
- C-6 Guide Student Study
- C-7 Direct Student Laboratory Experience
- C-8 Direct Students in Applying Problem-Solving Techniques
- C-9 Employ the Project Method
- C-10 Introduce a Lesson
- C-11 Summarize a Lesson
- C-12 Employ Oral Questioning Techniques
- C-13 Employ Reinforcement Techniques
- C-14 Provide Instruction for Slower and More Capable Learners
- C-15 Present an Illustrated Talk
- C-16 Demonstrate a Manipulative Skill
- C-17 Demonstrate a Concept or Principle
- C-18 Individualize Instruction
- C-19 Employ the Team Teaching Approach
- C-20 Use Subject Matter Experts to Present Information
- C-21 Prepare Bulletin Boards and Exhibits
- C-22 Present Information with Models, Real Objects, and Flannel Boards
- C-23 Present Information with Overhead and Opaque Materials
- C-24 Present Information with Filmstrips and Slides
- C-25 Present Information with Films
- C-26 Present Information with Audio Recordings
- C-27 Present Information with Televised and Videotaped Materials
- C-28 Employ Programmed Instruction
- C-29 Present Information with the Chalkboard and Flip Chart
- C-30 Provide for Students' Learning Styles

Category D: Instructional Evaluation

- D-1 Establish Student Performance Criteria
- D-2 Assess Student Performance: Knowledge
- D-3 Assess Student Performance: Attitudes
- D-4 Assess Student Performance: Skills
- D-5 Determine Student Grades
- D-6 Evaluate Your Instructional Effectiveness

Category E: Instructional Management

- E-1 Project Instructional Resource Needs
- E-2 Manage Your Budgeting and Reporting Responsibilities
- E-3 Arrange for Improvement of Your Vocational Facilities
- E-4 Maintain a Filing System
- E-5 Provide for Student Safety
- E-6 Provide for the First Aid Needs of Students
- E-7 Assist Students in Developing Self-Discipline
- E-8 Organize the Vocational Laboratory
- E-9 Manage the Vocational Laboratory
- E-10 Combat Problems of Student Chemical Use

Category F: Guidance

- F-1 Gather Student Data Using Formal Data-Collection Techniques
- F-2 Gather Student Data Through Personal Contacts
- F-3 Use Conferences to Help Meet Student Needs
- F-4 Provide Information on Educational and Career Opportunities
- F-5 Assist Students in Applying for Employment or Further Education

Category G: School-Community Relations

- G-1 Develop a School-Community Relations Plan for Your Vocational Program
- G-2 Give Presentations to Promote Your Vocational Program
- G-3 Develop Brochures to Promote Your Vocational Program
- G-4 Prepare Displays to Promote Your Vocational Program
- G-5 Prepare News Releases and Articles Concerning Your Vocational Program
- G-6 Arrange for Television and Radio Presentations Concerning Your Vocational Program
- G-7 Conduct an Open House
- G-8 Work with Members of the Community
- G-9 Work with State and Local Educators
- G-10 Obtain Feedback about Your Vocational Program

Category H: Vocational Student Organization

- H-1 Develop a Personal Philosophy Concerning Vocational Student Organizations
- H-2 Establish a Vocational Student Organization
- H-3 Prepare Vocational Student Organization Members for Leadership Roles
- H-4 Assist Vocational Student Organization Members in Developing and Financing a Yearly Program of Activities
- H-5 Supervise Activities of the Vocational Student Organization
- H-6 Guide Participation in Vocational Student Organization Contests

Category I: Professional Role and Development

- I-1 Keep Up to Date Professionally
- I-2 Serve Your Teaching Profession
- I-3 Develop an Active Personal Philosophy of Education
- I-4 Serve the School and Community
- I-5 Obtain a Suitable Teaching Position
- I-6 Provide Laboratory Experiences for Prospective Teachers
- I-7 Plan the Student Teaching Experience
- I-8 Supervise Student Teachers

Category J: Coordination of Cooperative Education

- J-1 Establish Guidelines for Your Cooperative Vocational Program
- J-2 Manage the Attendance, Transfers, and Terminations of Co-Op Students
- J-3 Enroll Students in Your Co-Op Program
- J-4 Secure Training Stations for Your Co-Op Program
- J-5 Place Co-Op Students on the Job
- J-6 Develop the Training Ability of On-the-Job Instructors
- J-7 Coordinate On-the-Job Instruction
- J-8 Evaluate Co-Op Students' On-the-Job Performance
- J-9 Prepare for Students' Related Instruction
- J-10 Supervise an Employer-Employee Appreciation Event

Category K: Implementing Competency-Based Education (CBE)

- K-1 Prepare Yourself for CBE
- K-2 Organize the Content for a CBE Program
- K-3 Organize Your Class and Lab to Install CBE
- K-4 Provide Instructional Materials for CBE
- K-5 Manage the Daily Routines of Your CBE Program
- K-6 Guide Your Students Through the CBE Program

Category L: Serving Students with Special/Exceptional Needs

- L-1 Prepare Yourself to Serve Exceptional Students
- L-2 Identify and Diagnose Exceptional Students
- L-3 Plan Instruction for Exceptional Students
- L-4 Provide Appropriate Instructional Materials for Exceptional Students
- L-5 Modify the Learning Environment for Exceptional Students
- L-6 Promote Peer Acceptance of Exceptional Students
- L-7 Use Instructional Techniques to Meet the Needs of Exceptional Students
- L-8 Improve Your Communication Skills
- L-9 Assess the Progress of Exceptional Students
- L-10 Counsel Exceptional Students with Personal-Social Problems
- L-11 Assist Exceptional Students in Developing Career Planning Skills
- L-12 Prepare Exceptional Students for Employability
- L-13 Promote Your Vocational Program with Exceptional Students

Category M: Assisting Students in Improving Their Basic Skills

- M-1 Assist Students in Achieving Basic Reading Skills
- M-2 Assist Students in Developing Technical Reading Skills
- M-3 Assist Students in Improving Their Writing Skills
- M-4 Assist Students in Improving Their Oral Communication Skills
- M-5 Assist Students in Improving Their Math Skills
- M-6 Assist Students in Improving Their Survival Skills

RELATED PUBLICATIONS

Student Guide to Using Performance-Based Teacher Education Materials
Resource Person Guide to Using Performance-Based Teacher Education Materials
Guide to the Implementation of Performance-Based Teacher Education
Performance-Based Teacher Education: The State of the Art, General Education and Vocational Education

For information regarding availability and prices of these materials contact—AAVIM, American Association for Vocational Instructional Materials, 120 Driftmier Engineering Center, University of Georgia, Athens, Georgia 30602, (404) 542-2586

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