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ABSTRACT

This document, which is designed to assist workplace education practitioners in business, education, and labor partnerships funded through the Massachusetts Department of Education's Workplace Literacy Program, includes materials about and/or for use in developing workers' mathematics skills. The first section, which examines the current state of the art of workplace math programs, lists math skills needed in the workplace and strategies for teaching mathematics in the workplace (teacher as facilitator, integration into other curriculum areas, collaborative learning, development of individual problem-solving strategies, importance of process, use of hands-on activities/manipulatives, and application of learning). In the second section, the author relates her own experiences in developing and presenting workplace mathematics programs to help employees accomplish the following: improve job performance, pass an examination/test, and become better-informed employees. The third section is a training plan for a 45-minute introductory training session for workplace educators interested in presenting a workplace mathematics course. Concluding the document is an annotated listing of eight resource materials. (MN)

The Commonwealth of Massachusetts

Department of Education

MATH IN THE WORKPLACE

SEPTEMBER, 1993

Massachusetts Board of Education

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Robert V. Antonucci
Commissioner

September, 1993

I am pleased to present this publication developed through our Massachusetts Workplace Education Initiative. This publication is part of a series of resources developed for and by workplace education practitioners in business, education, and labor partnerships funded through our Department's Workplace Literacy Program.

These resources are the result of our commitment to strengthening the capacity, knowledge base, and quality of the field and to provide much-needed and long-awaited information on highly-innovative and replicable practices. These resources also complement the curriculum framework of staff training and development initiatives that were successfully developed and piloted in conjunction with the field during the past fiscal year and represent an oustanding example of the Department's theme: " Working Together for Better Results."

Each of these publications was written by trainers and workshop presenters who have participated in the training of new workplace education staff. All publications provide invaluable information on important aspects of workplace education programming. All documents begin with an overview of the field or current-state-of-the-art section as it relates to the topic at hand. Then, they move into the practitioner's experience. Next, the training plan of presenters is discussed. Each publication ends with a list of resources.

We are confident that with this series of publications we have begun an exciting but challenging journey that will further support workplaces in their progression towards becoming high-performance work organizations.

Sincerely,

Robert V. Antonucci

Robert V. Antonucci
Commisioner of Education

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Donna Curry, Bob Bozarjian, Johan Uvin and Marie Narvaez

WORKPLACE EDUCATION RESOURCE SERIES:

Workplace Education Mentoring Pilot Project Final Report
17419-82-150-9/93-DOE

Workplace Education Sample Evaluation Report
17420-30-150-9/93-DOE

Workplace Education Mini-Course Pilot Project Final Report
17421-44-150-9/93-DOE

Transforming the Training Manual into a Learning Experience
17422-19-150-9/93-DOE

Math in the Workplace
17423-20-150-9/93-DOE

Learning Differently in Adult Education: Development of a Learning Disabilities Component At Hampden Papers, Inc.
17424-43-150-9/93-DOE

The Role of Counseling in Workplace Education:
Educational and Career Counseling at New England Medical Center
17425-66-150-9/93-DOE

September 15, 1993

MATH IN THE WORKPLACE

The National Workplace Literacy Program asked me to be a presenter for their mini-course. Along with a 45-minute presentation on "Math in the Workplace", I was requested to submit documentation on:

- ✓ The current state of the art in workplace math
- ✓ My own experience in the workplace
- ✓ Workplace math resources
- ✓ The training plan presented at the mini-course

I. CURRENT STATE OF THE ART

"Mathematics is the foundation of science and technology. Increasingly, it plays a major role in determining the strength of the nation's work force. Yet evidence all around us shows that American students are not fulfilling their potential in mathematics education."

--from "Everybody Counts,"
National Research Council

The United States has been given a very poor report card in math for the past few years. In 1983, the publication, A Nation at Risk, ignited the spark that inspired the National Council of Teachers of Mathematics (NCTM) to develop the Curriculum and Evaluation Standards for School Mathematics. The NCTM revisited the manner in which Americans are typically taught math in school versus the types of math skills we should possess. From this probe came a new math vision, a set of standards, for guiding teachers in their pursuit of quality math instruction in the K-12 classroom.

Based on the success of the NCTM in developing a set of standards, a group of practitioners in Massachusetts formed the ABE Math Team to actively explore ways to

implement NCTM's vision in the adult education classroom. The ABE Math Team participated in a year-long project in which it adapted the NCTM standards to meet the needs of adults, including those in the workplace.

As an active member of the Team, I whole-heartedly embrace the philosophy espoused in the adapted standards. Therefore, much of my work in this paper is a reflection of the revised standards. For example, the four key skills listed in the first section, "Math Skills for the Workplace", have been highlighted by the Math Team as being critical skills for all adults.

Math Skills for the Workplace: Even though some math skills are only needed for a specific workplace environment, there are other skills that should be woven throughout all math curricula. All math students should be able to:

☞ *Problem-solve and think critically* - Students need to develop a set of strategies to apply in various situations. Strategies should include calculator use, mental math, and use of formulae and procedures. Other strategies should also be available: for example, drawing a picture, guessing and checking, using manipulatives to create models.

☞ *Communicate using the language of math* - Not only should students be able to solve problems, but they should be able to explain how they work through problems. Being able to communicate about math is critical to understanding math concepts and their application in the workplace.

☞ *Make connections* - Math is not an isolated subject that is only applied in the context of the classroom. Skills learned in the classroom should be applied to a student's day-to-day life, whether it be at home or at work. Students should be able to connect math to other areas: sports, music, whatever. In the workplace, students should readily make direct connections to on-the-job situations. These connections help make math come alive for students.

☞ *Reason logically* - Adults need to be able to reason logically, especially in today's world with calculators and computers available to do many of the tedious calculations. Without this ability, they will simply have to trust whatever results show up on the calculator. Adults make decisions daily based on numbers. Being able to think logically will enable them to be better informed workers and citizens capable of making appropriate decisions.

Other math skills need to be included if they are presently needed in the workplace or the need is anticipated for future job performance. Skills of this nature will most likely include:

☞ *Estimating and converting within the metric system* (and sometimes between the English and metric measurements) - As companies become more global, their employees will need to become fluent in the language of the metric system.

☞ *Read, interpret, and create charts and graphs* - Companies trying to develop high performance organizations are relying more and more on front-line workers to collect data and analyze the results in order to make informed decisions.

☞ *Calculate linear, square, and cubic measurements* - Many adults have had little opportunity to become comfortable with the concept of area and volume, yet many workplaces expect their employees to be able to solve problems using various geometric shapes. Not only is determining one-, two-, and three-dimensional measures a relevant workplace skill, it is a life skill that adults should have.

☞ *Solve simple probability and sampling problems* - Workers are being asked more and more to contribute "not only their hands, but also their heads and their hearts". This means that workers must be able to help solve a variety of problems at the worksite, often related to quality issues. Workers with a basic understanding of probability and sampling, as well as mean, median, range, and standard deviation are better able to contribute to the betterment of the company by being able to suggest possible solutions.

Math Strategies for the Workplace: The strategies listed below should be applied to *all* math classrooms, including the workplace. Because they are critical to students being successful in math, they are worthy of discussion here.

☞ *Teacher as facilitator* - Let students do the problem-solving, the discovering. No longer are teachers the holders of all knowledge. Adults, and especially those in the workplace, come to the classroom with a great deal of experience. The teacher should be there to guide students to discover new knowledge by helping them make connections.

☞ *Integration into other curriculum areas* - Math should not be taught in isolation. Even when a company dictates that a math class is what is needed, you should bring curriculum areas can be introduced into the classroom, including writing. This ensures that students can make connections.

☞ *Collaborative learning* - Companies are encouraging teamwork and cooperation vs. competition in the workplace. Encouraging students in the classroom to work together provides an opportunity to model what is happening in the workplace.

☞ *Set of strategies* - Students need to understand that there is no one right way to get the answers. They should develop their own successful strategies in order to feel secure in tackling new problems. If they have reasoning skills, they can more readily choose the most appropriate tool for themselves and know whether their solutions make logical sense.

☞ *Importance of process* - Students need to realize that the process of working through a problem is extremely valuable. The goal of problem-solving is not just to arrive at the right answer (Sometimes there isn't just one "right" answer.), but to look at the steps taken to get to an answer. This analysis helps students develop stronger problem-solving and critical thinking skills.

☞ *Use of hands-on activities/manipulatives* - Students, whether they are in a workplace environment or not, gain better insight into math when they can be

active participants in the learning process. This includes providing activities where students can create models to replicate problem situations.

☛ *Application of learning* - One of the greatest benefits of teaching in a workplace environment is that students can immediately apply their new learning on the job. New skills are truly learned when they can be applied to something meaningful. In the workplace, contrived applications should not be necessary; real situations at the work site provide opportunities for immediate application of skills learned in the classroom.

II. EXPERIENCE

I have had experience in a variety of workplace settings. I have taught math overseas to soldiers and have worked in a variety of manufacturing sites, from developing computer software to processing frozen seafood to making computer boards. Each workplace environment is unique. Although there are some commonalities, I had to be prepared to adapt the math curriculum to each new environment.

In my workplace experience, I have found that there are several reasons why I might be asked to implement a math curriculum:

1. To improve job performance

- *Read, understand, and calculate math-related information*
  For example:

  ✓ Employees are often asked to complete forms related to the product or process. These forms often include math-related information, such as the number of parts needed per package. Employees are expected to read the information and then often translate it from one document to another. Additionally, employees are often required to compute totals or differences. Requirements may include documenting the number of pieces

that were completed in a day, or the number of bad pieces vs. the total number completed.

- *Plot points on graphs*

For example:

✓ Soldiers have to know how to plot target locations using grid coordinates when they are on the firing range.

✓ Employees at a computer manufacturing facility must determine where shorts are on a mother board; this entails an understanding the concepts of x- and y-axis as well as the ability to determine points between labeled tick marks along a scale.

- *Convert within the metric system, and sometimes to/from the English system*

For example:

✓ Employees working for companies operating in the global market, must be able to estimate the amount of materials needed for the job. The vendor could be American using the English system, but the product specifications may be labeled in metric measurements (or visa versa).

- *Use simple formulas*

For example:

✓ If employees are involved in making changes in a process, they may well be asked to make calculations involving formulae. At one computer manufacturing site, employees who monitor machines determine whether the pounds of pressure per inch (PSI) are accurate. In order to do this, the employees must first determine the number of square inches contained in the board by using a simple formula for area of a rectangle.

- *Understand the basics of sampling/QC-ing (Quality Control)*

For example:

✓ Checking for quality is done less and less at the end of the process and more and more during the making of the product. This means all employees who are involved in the process may be required to perform quality checks. Employees must check as well as document whether the

product is good or bad. They must have a basic understanding of how many bad ones can be made before having to decide that the process is not capable of making quality products. Employees at some manufacturing facilities are empowered to tell a line to s top when they find a certain number of bad parts. At other facilities, employees are instructed to tell their supervisor when they note a large number of defective parts. In each case, employees have some control over the process based on an understanding of quality control.

- *Read maps*

For example:

✓ Soldiers have to determine scale on a map in order to reach the appropriate target; this includes having to estimate distances.

- *Read, interpret, and create various charts and graphs*

For example:

✓ Employees who work in companies which have become involved in Total Quality Management (TQM) and/or Statistical Process Control (SPC) initiatives need to be well-versed in a variety of quality tools. Such tools may include Pareto charts, histograms, check sheets, cause and effect diagrams, control charts, and scatter diagrams.

I have found that manufacturing plants that use a great number of machines in their processes, such as ovens or drills, tend to use control charts and histograms. These companies expect their employees to be able to read data, plot the points, and determine next steps. Other companies in which employees count the number of defects in their products tend to use Pareto charts. Creating a math curriculum for these individuals is much simpler than for those having to interpret and create histograms and control charts.

2. **To pass an exam/test**

For example:

✓ Soldiers retake the Armed Services Vocational Aptitude Battery (ASVAB) to qualify for re-enlistment in the military or to qualify for a different occupational specialty. The test consists of ten subtests, three of which are a direct measure of an individual's math ability: Arithmetic Reasoning, Numerical Operations, and Mathematics Knowledge.

✓ Production supervisors take the Certified Quality Technician Exam (CQT), a nationally recognized exam sponsored by the American Society for Quality Control, to bring credibility to themselves and to the company.

✓ Employees, whether it be the military, industry, or business, take the GED (General Education Development) tests as a step in their pursuit of continued growth and improvement.

3. **To be a better-informed employee**

- *Understand benefits packages*

For example:

✓ Employees are sometimes offered tremendous benefits to encourage them to stay with the company. Benefits at one company I worked with included an investment package in which the company was willing to invest a proportionate amount of what the individual invested; this was not an easy topic to explain - especially because the employees were not native English speakers! Not only was the vocabulary difficult, but so were the math concepts involved in teaching about investments.

- *Understand financial information, such as pay stubs*

For example:

✓ At one manufacturing plant the payroll department is switching from weekly to biweekly paychecks. The company is concerned that employees

may have difficulty adjusting to this new situation and have asked for help in designing a course to teach employees the basics of budgeting.

- *Understand metric system*

For example:

✓ This is especially true for soldiers serving overseas. In order to be able to function in a foreign country, military personnel and their family members are offered courses to familiarize them with the basics of the metric system, including weight, volume, and length. Many military bring their cars with American specifications (speedometer in miles, not kilometers) overseas with them. Without estimation skills to compare miles to kilometers, soldiers can find that speeding fines can be very large. Additionally, speeding tickets can negatively impact a soldier's career.

- *Balance checkbook*

For example:

✓ Again, I'll use the example of the military, since military personnel can be involuntarily released from the military if they are convicted of writing bad checks. Since soldiers may be quite capable in their jobs, the Department of the Army believes that, with a little education on check writing, the careers of many good soldiers can be saved.

- *Understand stocks and bonds*

For example:

✓ One computer company offered stock shares to its employees. Many workers thought of this as a wonderful opportunity to invest in the company and purchased shares. As the prices of the shares later began to fluctuate, it was important that employees understood what was happening in order to make informed decisions about their finances.

- *Determine conversion rates*

For example:

✓ Military personnel overseas must learn how to convert American dollars into the local currency. This request is specific to military personnel overseas. Although most of you will never teach overseas, I feel these examples show how math curriculum must be designed specifically for the workplace needs. One generic math curriculum would not successfully meet all the unique needs of the population in the workplace.

III. TRAINING PLAN (for a 45-minute presentation for introducing workplace educators to "Math in the Workplace")

(5 minutes) Introductions/Objectives/Set environment:

Objectives:

> To provide examples of what can occur in the math classroom

> To develop some basic rules of thumb to think about in designing a workplace math curriculum, no matter what the math level or industry or business

Set environment:

> It is acceptable to make mistakes; it is part of the learning process

(15 minutes) Activity I:

Step 1: Begin by simply asking participants to figure 75% of 200. Do not give them any other instructions, but be sure to have pencils, paper, and calculators available at each table.

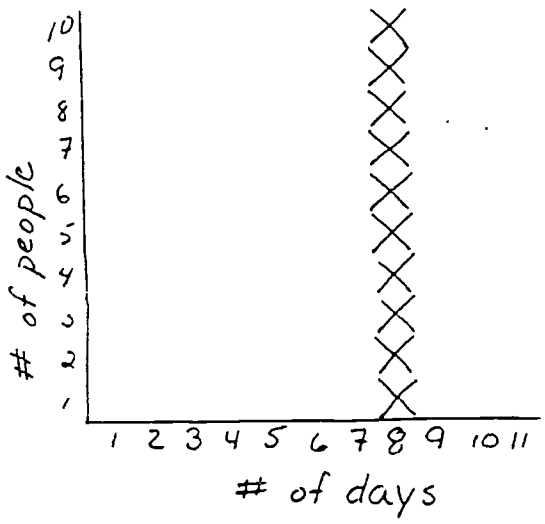
Step 2: Discuss how participants arrived at their answer. Try to get a many different strategies as possible. Hopefully you will find someone who used the calculator, someone who used pencil and paper, and others who figured out the answer in their heads. You may even find an individual who, rather than solve it himself, simply asked his neighbor for the answer.

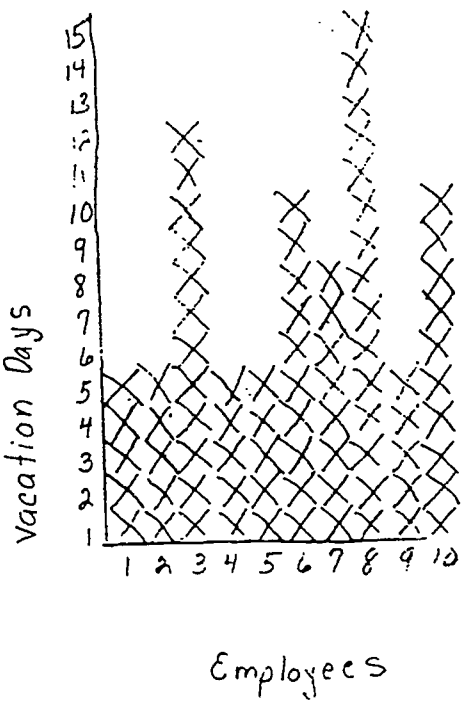
Step 3: Ask participants which they thought was the most appropriate method for solving the problem (there is NOT a most appropriate method!). Discuss the importance of our job as adult educators to help students develop their own strategies for solving problems - whatever is most comfortable for them. We can offer them a wide variety of tools, but then they choose which ones they want to use and when they want to apply them.

(15 minutes) Activity II:

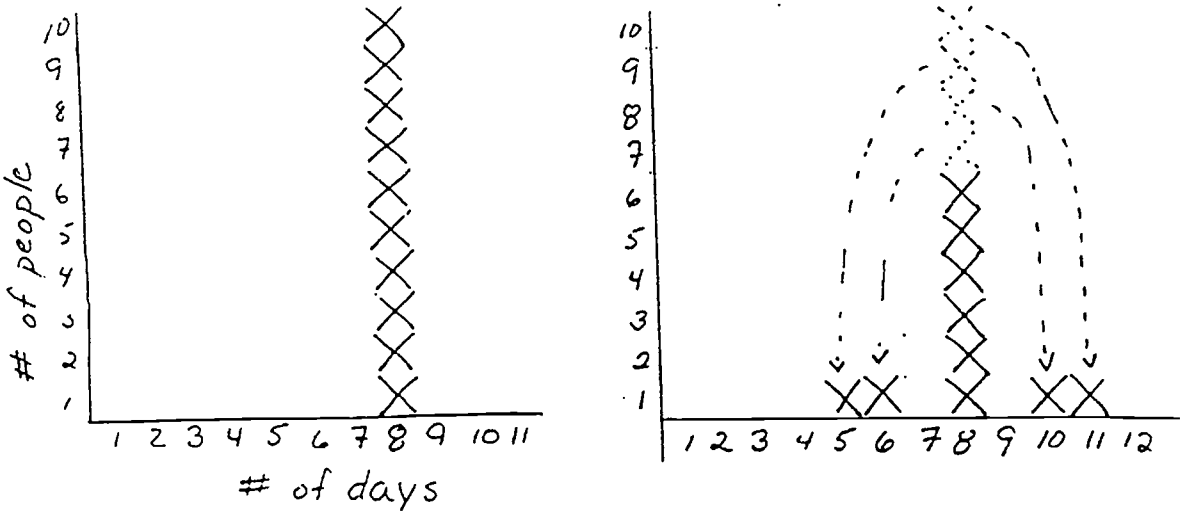
Step 1: Provide each group with stickies. Tell the whole group that the average days of vacation for an organization of ten people is eight. Ask each team (no more than three or four) to represent this bit of information on a bar chart (using stickies and flip chart paper).

Step 2: Compare what each team's chart. Discuss the differences. This activity is intentionally a little vague so that groups may come up with different interpretations of the same bit of information. For example, here are two different interpretations of the same set of directions:





Step 3: Share a simple way to explain how mean (average) can be represented by the same numerical amount but look very different graphically. Begin by placing all 10 stickies in a column under 8 days - obviously this shows a mean of 8. Then let participants help you move stickies both left and right to other days while still maintaining a mean of 8. Participants will begin to see how to model what is represented by the term mean by manipulating the data.



(5 minutes) Rules of Thumb Activity:

Step 1: Follow up with a discussion on Rules of Thumb for strategies for the Workplace (participants should have a copy of a blank page labeled "Strategies for the Workplace"). As participants share their reaction to the activities above, jot their ideas on flip chart paper. At the same time, they should be adding the ideas to their own page. These jottings become guidelines for participants to use in implementing their own workplace math curriculum.

Hopefully, the participants will address the following key points as necessary for the success of a math program:

- ☞ Allow for multiple ways (processes) to get to the answer
- ☞ Create opportunities for practice in:
  - mental math
  - paper/pencil calculations
  - calculator
- ☞ Use manipulatives (stickies, graph paper, and large flip chart paper are considered manipulatives since participants are able to "manipulate" them)
- ☞ Encourage teamwork/collaboration
- ☞ Use friendly numbers when introducing a concept (Notice that in both activities above, only whole number were used)
- ☞ Encourage problem-solving rather than rote calculations
- ☞ Make connections:
  - to other math concepts
  - to the workplace
  - to real life
  - to other curriculum areas
- ☞ Encourage talking and writing about math

(5 minutes) Close/Evaluation:

> To determine what worked well and what could be improved

Materials needed:

Flip charts:

with heading "What is 75% of 200?"
with heading "Rules of Thumb"
with heading "What Worked/What could be Improved"
blank sheets (for bar charts)

Stickies
Calculators
Pencils/Paper

IV. RESOURCES

No one text/workbook is the solution to any math curriculum. Most commercial materials still isolate fractions from decimals from percents rather than present the three as interrelated. Few encourage mental math. Instead, texts tend to show how to figure 10% of a number by using pencil and paper and following an algorithm, or by using a calculator vs. the simpler, more realistic technique of solving 10% using mental math.

Use texts as a reference - for sample problems and explanations, then adapt the materials to the specific needs of the workplace environment.

Below is partial listing of materials that I have used as resources in my teaching math in the workplace. Whenever possible, I have included a phone number for your convenience.

Arithmetic Teacher: Although designed for the middle grades, this monthly magazine offers activities that can often be readily adapted to the adult education classroom. (ISSN: 0004-136X; Phone: (703) 620-9840)

Curriculum and Evaluation Standards for School Mathematics: An excellent source for gaining a clearer understanding of where the teaching of mathematics is heading. (Available through the National Council of Teachers of Mathematics, Inc. 1906 Association Drive. Reston, VA 22091; ISBN: 0-87353-273-2)

The Memory Jogger: A handy pocket guide of tools for the workplace, including Pareto charts, histograms, and control charts. (Available from GOAL/QPC Phone: (508) 685-3900)

Number Power 8 Analyzing Data: A good reference for helping student develop an understanding and appreciation for statistics. (Available through Contemporary Books ISNB: 0-8092-4213-3; Phone: (312) 782-9181)

Priority Math: Although created for GED math instructors, many of the suggested activities can be used in the workplace classroom as well. (Available for check-out through your local SABES representative)

Quality Quest: Brings clarity to histograms, control charts, check sheets, and Pareto charts. Sample activities are included which can be adapted for use in *any* classroom. (Available free from the Department of Education's Workplace Education Initiative)

Statistical Methods for Improving Performance: Offers fairly reasonable explanations of the various quality tools, especially check sheets, line and bar charts, and scatter diagrams. This program offers videos and computer software also. (Concourse Corporation)

Teamwork: the Quality Message: Builds on some of the topics introduced in Quality