DOCUMENT RESUME

ED 440 848 SE 063 433

AUTHOR	Forman, Susan L.; Steen, Lynn Arthur
TITLE	Making Authentic Mathematics Work for All Students.
PUB DATE	2000-00-00
NOTE	13p.; Contribution to a Working Group at the Meeting of the International Congress on Mathematics Education (Seville, Spain, 1986).
AVAILABLE FROM	For full text: http://www.stolaf.edu/people/steen/papers/work.html.
PUB TYPE	Opinion Papers (120) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Academic Standards; Educational Change; Elementary Secondary Education; *Equal Education; *Mathematics Education; *Relevance (Education)

ABSTRACT

In an attempt to improve education for all students, U.S. educators and employers have independently developed voluntary national standards for academic subjects and for various occupational skill clusters. These standards pose a special challenge to mathematics: to develop a core curriculum suitable for all students that is grounded in authentic, concrete tasks in which important mathematics is embedded in meaningful and realistic problems from life and work. A core curriculum rooted in credible and concrete problems refining only elementary tools will make high school mathematics work for all students. (Contains 21 references.) (Author)

Making Authentic Mathematics Work for All Students

by

Susan L. Forman
Lynn Arthur Steen

Making Authentic Mathematics Work for All Students

Susan L. Forman and Lynn Arthur Steen

In *Education for Mathematics in the Workplace.* Annie Bessot and James Ridgway, Editors. Dordrecht, Netherlands: Kluwer Academic Publishing, (forthcoming).

(Contribution to a working group on the role of mathematics in the world of work at the 1986 meeting of the International Congress on Mathematics Education in Seville, Spain.)

Abstract: In an attempt to improve education for all students, U.S. educators and employers have independently developed voluntary national standards for academic subjects and for various occupational skill clusters. These standards pose a special challenge to mathematics: to develop a core curriculum suitable for all students that is grounded in authentic, concrete tasks in which important mathematics is embedded in meaningful and realistic problems from life and work.

Historically, education in the United States, like Caesar's Gaul, has been divided into three tracks–academic, vocational, and general–that differ greatly in goals, status, size, and outcomes. Although two out of three U.S. secondary school students say that they intend to go to college, and sixty percent do begin full time postsecondary study, only one-third actually complete a college-preparatory program while in high school [National Center for Education Statistics (NCES), 1992]. In contrast, only about fifteen percent of high school students pursue a vocational program, and only half of them (approximately eight percent) complete it [NCES, 1996]. The remaining students receive a "general" diploma that does not prepare them either for the world of work or for higher education.

Not surprisingly, the academic track is the locus of prestige for students, parents, and teachers. In recent years, political pressure has aimed the spotlight of academic accountability on calculus as a metaphor for educational quality. Although calculus has historically been principally a postsecondary subject in the United States, it is now a chief public indicator of high quality secondary schools. Intense public pressure to measure schools by the number of students who earn credits in the Advanced Placement (AP) calculus program has effectively lowered the status of most applied and vocational options. Even the National Collegiate Athletic Association (NCAA), which regulates scholarships for college athletes, is now unwilling to certify high school mathematics courses that are deemed too applied or vocational.

With all this emphasis on preparation for college, neither parents nor politicians pay much attention to preparation for work. In contrast to other nations, the United States has no tradition of high-quality apprenticeship education for students in the final years of secondary education. Most states require secondary school students to complete certain courses (counted in so-called "Carnegie units") that generally do not allow credits for experiential learning. Although some vocational programs do include work-based (or "co-op") components, most rely on school-based exposure to vocational subjects such as automotive repair or carpentry. Being isolated from current industrial practice, these school-based programs quickly become outdated. Without a continuing commitment to cooperation, it is very difficult for teachers, curricula, and textbooks to keep pace with the rapid changes and increasing rigor of the contemporary high-performance workplace.

These two handicaps–operating in the academic shadow of calculus and lacking the rigor of contemporary industrial requirements–burden vocational education in the United States with low status that seems very difficult to eradicate, notwithstanding evidence of high-paying technical jobs in many industries. Indeed, increasing demand created by worldwide economic trends (e.g., ISO standards, international subcontracting, and information technology) combined with an educational system that is out of step with the needs of the modern workplace have created a severe shortage of qualified technical workers in the United States [Marshall & Tucker, 1992; Judy, 1997]. None of the three educational tracks commonly offered by U.S. secondary schools prepares students to meet the challenges of careers in the modern international economy.

Surprisingly, much the same can be said about preparation for postsecondary education. In fact, weak mathematics is the most common source of inadequate preparation for college and university programs. It is not uncommon in the United States for secondary school graduates to begin their postsecondary mathematics with elementary or intermediate algebra, or even arithmetic (see Table 1) [Loftsgaarden, Rung, & Watkins, 1997]. Moreover, a recent survey [National Association of Manufacturers, 1997] reveals that more than half of current manufacturing employees lack basic skills in mathematics and in document literacy (e.g., reading diagrams, graphs, and flowcharts).

The Standards Movement

Educators and employers responded to these problems by creating standards for academic subjects and for occupational skills. The movement in the United States for academic standards began in mathematics with the publication of *Curriculum and Evaluation Standards for School Mathematics* [National Council of Teachers of Mathematics (NCTM), 1989]. Subsequently,

K-12 standards have been developed in history, language arts, science, fine arts, foreign languages, and other subjects, as have standards for the first two years of college mathematics before calculus [American Mathematical Association of Two-Year Colleges, 1995].

Employment standards were first expressed in a widely-read government report, *What Work Requires of Schools* [Secretary's Commission on Achieving Necessary Skills (SCANS), 1991]. This influential report outlines five competencies (using resources, information, systems, interpersonal skills, and technology) built on a three-part foundation (basic skills, thinking skills, and personal qualities) required of any employee in any job. Subsequently, more focused occupational skill standards were developed for entry level positions in two dozen different employment clusters ranging from industrial laundering to photonics and from retail trades to advanced high performance manufacturing. (Appendix A contains a complete list of these clusters; related Web sites are listed in Appendix B.)

Not surprisingly, the word "standards" means different things to different people. For NCTM, a standard expresses a vision about what is valued–a banner behind which to rally support for improvement in mathematics education. For industry, standards specify the knowledge and competencies required to perform successfully in a specific occupation [Bailey, 1997]. For the public, standards provide both a goal (what should be done) and a measure of progress toward that goal (how well it is done) [Ravitch, 1995].

Both sets of standards–academic and occupational–are voluntary. Autonomy of schools and businesses from governmental authority is an abiding value of the American political system. Just the idea of national "standards" is enough to make many individuals suspicious because externally imposed mandates are seen as an unconstitutional intrusion on the independence of local communities. To coordinate the emerging occupational skill standards, in 1995 the United States

Congress established the National Skills Standards Board (NSSB). However, in the face of widespread criticism about federal intrusion in education, the Congress rescinded a parallel effort to coordinate or promote academic standards.

In addition to being voluntary, the two sets of standards, like the academic and vocational tracks in the schools, are totally independent. Educators developed academic standards with virtually no input from employers; business and industry developed occupational skill standards with virtually no input from educators. Thus, for example, what the two sets say about mathematics is very different. NCTM recommends a mathematically rich eleven-year curriculum focused on problem solving, communication, reasoning, and making connections; the occupational skill standards, by and large, call only for lower-level mathematical skills that are normally covered at the transition from primary to secondary education. These different visions of essential mathematical skills, amplified by economic analysis [Murnane & Levy, 1996], send mixed messages to teachers and schools.

Although the academic and occupational standards address different issues and outline different expectations, they are surprisingly consistent in their vision of effective pedagogy. All the standards argue or imply that learning is enhanced when embedded in rich, authentic contexts; when students engage with each other and with the world around them; and when students are expected to experience, explore, and explain. Both the occupational and academic standards clearly recognize the limitations of traditional textbook learning–what Lee Shulman [1997] has termed the challenges of amnesia (loss of learning), illusory understanding (idols of learning), and inert ideas (uselessness of learning). The standards endorse, either implicitly or explicitly, Shulman's prescription for effective learning: activity, reflection, and engagement.

Finally, despite the enthusiasm of their developers and supporters, neither set of standards has met with widespread approval. School mathematics standards have been intensely controversial, with politicians and educators taking sides through newspaper editorials and political wrangling over such issues as basic skills, mathematical rigor, calculators, and contextual problems. (Similar arguments have plagued the standards in other academic subjects, especially history and language arts.) In contrast, the occupational skill standards have been largely ignored, or greeted with apathy. Few educators know anything about them, as do few managers in industry. As a consequence, occupational skill standards have stirred neither public interest nor passion.

Status, Equity, and Tracking

The goal of both educators and employers is to increase the quality and rigor of students' school experiences to ensure that graduates are well prepared for work and for postsecondary education. Although many schools view this as a choice–either work or college, either vocational programs or academic programs–many educators and politicians argue that all students should leave secondary school well prepared for *both* work and further education:

- Most of today's careers require some form of postsecondary preparation.
- Virtually all employees must expect to periodically update their knowledge and skills through some form of postsecondary study.
- Many students graduate from college with little knowledge of or commitment to any career or vocation; most would benefit from an early introduction to the world of work.
- Class and racial inequities in U.S. society are magnified by educational tracking that holds some students, primarily poor or minority, to lower standards than others.

NCTM argues in its *Standards* that all students should master a common core of mathematics.

Separate tracks for students with different interests could achieve this goal, but only if each maintains a similar set of performance expectations. What is not acceptable, in this view, is a vocational or general track that sells students short by expecting little and accepting even less. Such programs, still too common in U.S. schools, offer the least education to students who have the greatest need.

To meet these challenges mathematics educators need to find a way to coordinate (or integrate) the mathematics and occupational skill standards so that students leave secondary school mathematically prepared both for postsecondary education and for the high performance workplace. However, unless parents, teachers, and students perceive that the mathematical expectations of what is now often called "applied academics" is of comparable challenge and rigor to that of traditional academic programs, preparation for work in the schools will never achieve the same status as preparation for college or university.

Beyond Eighth Grade

One reason mathematics for work is held in such low esteem among parents and teachers is the perception that employers expect primarily basic computational skills. To be sure, they do expect basic skills first; this is the unmistakable message both of the SCANS report, the occupational skill standards, and public opinion [Wadsworth, 1997]. But beyond basic skills, business and industry expect three kinds of mathematical performance rarely taught in the schools:

- Problem solving that relies on sophisticated uses of relatively elementary mathematical tools [Forman & Steen, 1995]. In contrast to typical secondary school mathematics problems that consist primarily of routine manipulations involving advanced topics such as trigonometric identities and quadratic equations, these kinds of problems are more concrete and more common, yet just as challenging.

- Modern management tools such as systems analysis, PERT charts, and statistical quality control [Mathematical Sciences Education Board (MSEB), 1995]. In contrast to typical secondary school topics such as factoring, finding roots, and solving equations that are included as preparation for the study of calculus, these other tools would prepare students to work in tomorrow's world.

- Mathematical habits of mind that are embedded in contexts such as measurement, management, and quality control [Packer, 1997]. In contrast to the easily recognizable mathematical skills of arithmetic, geometry, and algebra, these distinctively mathematical patterns of thought underlie many aspects of the occupational skills standards but are rarely identified as *mathematical* skills.

Although many parents and teachers in the United States do not yet recognize a need to include these kinds of mathematical tasks in the traditional curriculum, others agitate for transformation (or at least enrichment) of secondary school mathematics to include more authentic tasks that reflect the ways in which mathematics arises in life and work. For some the goal of such a transformation is primarily vocational (to ensure that students are better prepared for work), while for others the goal is mostly pedagogical (to motivate more students to learn high quality mathematics).

Two current initiatives seek to advance this agenda. The U. S. National Academy of Sciences recently published a collection of essays and mathematical tasks suggesting ways to connect secondary school mathematics to the kinds of challenges students will likely encounter at work and in their daily lives [MSEB, 1998]. And the National Center for Research in Vocational Education (NCRVE) sponsored a workshop entitled "Beyond Eighth Grade" to highlight the rich mathematics embedded in workplace tasks and to strengthen the case for both rigorous academic standards in vocational education and authentic workplace applications in academic programs [Forman & Steen, 1997].

These initiatives identified several fundamental questions concerning secondary school mathematics, including:

- Should students be encouraged to spend time on newer topics more in demand by industry (e.g., statistical quality control, spreadsheets) even if it means delaying the study of calculus?
- How can mathematics teachers who have never worked outside the schools be expected to teach authentic workplace applications with competence and confidence?
- Can a single mathematics curriculum provide both what industry wants of high school graduates and what higher education expects of entering students?
- Are there many authentic workplace applications of (upper) secondary school mathematics?

The last question, which is really a prerequisite to all the others, is surprisingly difficult to answer.

Authentic Tasks

Mathematics is known by the problems it keeps. Children's homework reminds parents of their own mathematics homework. Each generation's successes (and traumas) are passed on to the next. For many, algebra is a rite of passage. Thus old problems recur like clockwork in textbooks and on tests. In the United States, entrance examinations for postsecondary education are filled with predictable problems:

> A bag contains 28 pounds of sugar which is to separated into packages containing 14 ounces each. How many such packages can be made?
>
> The sum of the first three of six consecutive integers is 27. What is the sum of the last three?
>
> If the length of a rectangle is increased by 20 percent and the width is decreased by 20 percent, by how much is the area changed?
>
> What percent of 1/2 is 3/4?

So too are exams that are required of prospective secretaries, postal workers, or plumbers:

> Find the next two numbers in the series 27, 26, 24, 23, 21, 20, 18, ...
>
> If C = (5/9)(F - 32), what is C when F is 50?
>
> 30% of 420 employees in a department are clerks and 1/7 are typists. What is the difference between the number of clerks and the number of typists?
>
> If 12 word processing center employees can produce 12,000 documents in 20 days, how many documents can 18 word processors produce in 30 days?
>
> Mark is now four times as old as his brother Stephen. In one year Mark will be three times as old as Stephen will be then. How old was Mark two years ago?

Virtually no one ever encounters problems like these except in mathematics courses, yet they remain the staple of entrance examinations both for employment and for higher education. At work, employees are much more likely to encounter problems such as the following, which are drawn from discussions with real people working at real jobs:

Ordering Drapes. A customer asks a sales associate in a large department store for advice about ordering draperies for a living room. The customer has a photograph from a magazine of the desired window treatment and a sketch of the room including locations of the windows and height of the ceiling. The salesperson needs to advise the customer on a number of issues. Will the treatment translate well to the customer's home? Is the scale of the room (and of the windows) appropriate? How can they take into account a difference in ceiling height? If the desired treatment makes sense in the customer's room, then the sales person needs to determine how much material needs to be ordered.

Arranging a Stockroom. A typical shoe store has a crowded stockroom in which several thousand boxes of shoes are stored. The boxes are labeled by manufacturer, style, color, and size, and are stacked floor to ceiling on rows of shelves. How should the shoes be arranged in the stockroom? Obvious options are by manufacturer, by style, by size, by frequency of demand, or by date of arrival. The main concern is getting shoes out to customers quickly and minimizing the amount of time spent returning shoes to their correct location once a transaction has been completed. But other concerns need to be considered as well. For example, when replacement stock or new styles arrive, clerks need to add the shoes to the stockroom in the appropriate locations. And clerks need to check the inventory weekly to verify records of change due to sales and receipt of new shoes as well as to identify misshelved boxes.

Machining Parts. In most manufacturing industries, machinists operate precision cutting and drilling tools to fabricate parts to designers' specifications. Often these machines are controlled by computers, but the machinist must provide the computer with the proper calculations. For example, a block to be machined sits on a compound sine plate five inches square, as shown in Figure 1. Determine the tilt of the upper and lower plates, and the number of inches of blocking required to achieve this tilt in order to level the block.

Scheduling Elevators. In some tall buildings all elevators can travel to all floors, while in others certain elevators are restricted to stopping only at certain floors. Under what circumstances is it advantageous to have elevators that travel only to certain floors? Does it make a difference if the building is a hotel, an apartment building, or an office building?

Maintaining a Pool. The chlorine used to control microorganisms in a swimming pool dissipates in reaction to bacteria and the sun at a rate of about 15% per day. The optimal concentration of chlorine is between 1 and 2 parts per million (ppm), although 3 ppm is safe for swimming. How much chlorine should be added each day to maintain an appropriate concentration? Could one get by with a regimen of adding chlorine only once per week? What about twice a week?

Leasing Space. A small start-up company needs to lease space for its staff and operations. Available sites differ in such factors as gross square footage (on which the rent is based), usable square footage (omitting hallways, stairways, bathrooms, elevator shafts, and other service space); outside window space; and compactness (the ratio of perimeter to area, which indicates how spread out the office space is). This information needs to be calculated from floor plan drawings and then organized in a manner that will permit easy comparison.

These kinds of authentic mathematics-rich tasks–embedded in real contexts, mixing hard and soft data, amenable to multiple approaches and conclusions–are typical of life and work. Although they don't look like typical mathematics problems, they serve as effective Trojan horses for all the basic skills of school mathematics: (e.g., numbers, equations, graphs, measurement, geometry). At the same time, these tasks give students much needed experience in the more subtle cognitive skills required to employ mathematical thinking in the analysis of contextually rich tasks.

Challenges

School mathematics in the United States builds on a long tradition of tracking which ill-serves many students. This tradition is being challenged by new academic standards that set high expectations for all students and by occupational skill standards that express what students need for entry level employment. While these standards have some important elements in common, they do not yet convey a unified vision–especially not of secondary school mathematics.

By seeking elements important to both sets of standards one can, however, discern criteria for secondary school mathematics that could form the basis for a unified core curriculum that serves both aims (Forman & Steen, 1998):

- Beyond arithmetic, all students should take a three-year core of mathematics consisting of statistics, geometry, and algebra in roughly equal proportion. These subjects represent the three great strands of mathematics–numbers, space, and symbols–as well as the basic mathematical needs of citizens for life and work.
- In this three-year core of secondary school mathematics, students should work extensively on authentic, concrete, contextual problems that require sophisticated multi-step reasoning with elementary mathematical tools. Such tasks will motivate students to master the use of important basic skills before moving on to more advanced and abstract topics required for postsecondary education.
- Students who complete this core can then choose among advanced electives based on their interests. One option would be a precalculus course that introduces the algebraic manipulations and elementary functions that form the foundation of calculus. Another option would be advanced computer-assisted geometry (e.g., CAD/CAM) or statistical tools for quality control (SQC).

A core curriculum adhering to these principles, rooted in credible and concrete problems requiring only elementary tools, will make high school mathematics work for all students.

References

American Mathematical Association of Two-Year Colleges. (1995). *Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus.* Memphis, TN: Author.

Bailey, Thomas R. (1997). *Integrating Academic and Industry Skill Standards.* National Center for Research in Vocational Education. Berkeley, CA: University of California.

Commission on Skills and the American Work Force. (1990). *America's Choice: High Skills or Low Wages.* Rochester, NY: The National Center on Education and the Economy.

Forman, Susan L. & Steen, Lynn Arthur. (1995). Mathematics for Work and Life. In Iris Carl (Ed.), *Seventy-Five Years of Progress: Prospects for School Mathematics* (pp. 219-241). Reston, VA: National Council of Teachers of Mathematics.

Forman, Susan L. & Steen, Lynn Arthur. (1997). Beyond Eighth Grade. National Center for

Research in Vocational Education.

Forman, Susan L. & Steen, Lynn Arthur. (1998). *The New Basics: Mathematics for Life and Work.* New York, NY: National Center for Research in Vocational Education.

Judy, Richard W. & D'Amico, Carol. (1997). *Workforce 2020: Work and Workers in the 21st Century.* Indianapolis, IN: Hudson Institute.

Loftsgaarden, Don O., Rung, Donald C., & Watkins, Ann E. (1997). *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 1995 CBMS Survey.* Washington, DC: The Mathematical Association of America.

Marshall, Ray & Tucker, Marc. (1992). *Thinking for a Living: Work, Skills, and the Future.* New York, NY: Basic Books.

Mathematical Sciences Education Board. (1995). *Mathematical Preparation of the Technical Work Force.* Washington, DC: National Research Council.

Mathematical Sciences Education Board. (1998). *High School Mathematics at Work.* Washington, DC: National Academy Press.

Murnane, Richard and Levy, Frank. (1996). *Teaching the New Basic Skills: Principles for Educating Children to Thrive in a Changing Economy.* New York, NY: The Free Press.

National Association of Manufacturers. (1997). The Skilled Workforce Shortage.

National Center for Education Statistics. (1992). *National Education Longitudinal Study: Second Follow-Up and High School Transcript Files.* Washington, DC: U.S. Department of Education.

National Center for Education Statistics. (1996). *Vocational Education in the United States: The Early 1990s.* Washington, DC: U. S. Department of Education.

National Council of Teachers of Mathematics. (1989). *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: Author.

Packer, Arnold. (1997). Mathematical Competencies that Employers Expect. In Lynn Steen (Ed.), *Why Numbers Count: Quantitative Literacy for Tomorrow's America* (pp. 137-154). New York, NY: The College Board.

Ravitch, Diane. (1995). *National Standards in American Education: A Citizen's Guide.* Washington DC: The Brookings Institution.

Secretary's Commission on Achieving Necessary Skills (SCANS). (1991). *What Work Requires of Schools: A SCANS Report for America 2000.* Washington, DC: U. S. Department of Labor.

Shulman, Lee F. (1997). Professing the Liberal Arts. In Robert Orrill (Ed.), *Re-imagining Liberal Learning in America* (pp. 151-173). New York, NY: The College Board.

Wadsworth, Deborah. (1997). Civic Numeracy: Does the Public Care? In Lynn Steen (Ed.), *Why Numbers Count: Quantitative Literacy for Tomorrow's America* (pp. 11-22). New York, NY: The College Board.

Appendix A: Occupational Skill Standards

Administrative Support:	Professional Secretaries International, Kansas City, MO
Agricultural Biotech:	National Future Farmers of America Foundation, Alexandria, VA
Automotive Technicians:	National Automotive Technicians Education Found., Herndon, VA
Bioscience:	Educational Development Center, Newton, MA
Chemical Technicians:	American Chemical Society, Washington, DC
CADD:	Foundation for Industrial Modernization, Washington, DC
Construction:	Laborers AGC Education & Training Fund, Pomfret Center, CT
Electronics:	American Electronics Association, Washington, DC
Electronics Technicians:	Electronics Industries Foundation, Washington DC
Electrical Construction:	National Electrical Contractors Association, Bethesda, MD
Forest & Wood Products:	Foundation for Industrial Modernization, Washington, DC
Groceries:	National Grocers' Association, Reston, VA
Hazardous Materials:	Center for Occupational Research and Development, Waco, TX
Health:	Assoc. for the Advancement of Health Education, Reston, VA
Health Care:	Far West Laboratory for Educ. R&D, San Francisco, CA
HVAC:	Vocational-Technical Educ. Consort. of States, Decatur, GA
Hospitality &Tourism:	Council on Hotel, Restaurant & Institutional Educ., Washington, DC
Human Services:	Human Services Research Institute, Cambridge, MA
Industrial Laundering:	Institute of Industrial Launderers, Washington DC
Manufacturing:	National Coal for Advanced Manufacturing, Washington DC
Metalworking:	National Tooling and Machining Assoc, Fort Washington, MD
Photonics:	Center for Occupational Research and Development, Waco, TX
Physical Education:	National Assoc for Sport and Physical Education, Reston, VA
Printing :	The Graphic Arts Technical Foundation, Sewickley, PA
Retail:	National Retail Federation, Washington DC
Welding:	American Welding Society, Miami, FL

Appendix B: Selected Web Sites

Mathematics and Science Education:

Amer. Math. Assoc. of Two-Year Colleges (AMATYC): <www.amatyc.org>
Educational Resources Information Center (ERIC): <inet.ed.gov/EdRes/EdFed/ERIC.html>
Eisenhower National Clearinghouse (ENC): <www.enc.org>
EXTEND: Broadening Reform in Mathematics Education: <www.stolaf.edu/other/extend>
National Council of Teachers of Mathematics: <www.nctm.org>

U. S. Government Offices:

National Center for Education Statistics (NCES): <www.ed.gov/nces>
School-to-Work National Office: <www.stw.ed.gov>
U.S. Department of Education: <www.ed.gov>
U.S. Department of Labor: <www.dol.gov>

Occupational Skill Standards:

American Society for Agricultural Engineers (ASAE): <wwww.cord.orgww.asae.org>
Center For Occupational Research and Development (CORD): <www.cord.org>
Education Development Center (EDC): <www.edc.org>
Electronics Industries Association (EIA): <www.eia.org>
Graphic Arts Technical Foundation (GATF): <gatf.1m.com>
Nat'l Center for Research in Vocational Educ. (NCRVE): <vocserve.berkeley.edu>
National Center on Education and the Economy (NCEE): <www.ncee.org>
National Coalition for Adv. Manufacturing (NACFAM): <www.bmpcoe.org/nacfam>
National Retail Federation (NRF): <www.nrf.com>
National Skill Standards Board (NSSB): <www.nssb.org>

Business and Industry:

Business Coalition for Educational Reform (BCER): <www.bcer.org>
Committee on Economic Development: <www.ced.org>
National Alliance of Business (NAB): <www.nab.com>

Reports and Publications:

Advanced High-Performance Manufacturing: <www.bmpcoe.org/nacfam/skilstd1.html>
Chemical Technicians Skill Standards: <www.acs.org/pafgen/slreact/environ/2-3e.htm>
Crossroads in Mathematics (AMATYC): <www.richland.cc.il.us/imacc/standards>
Curriculum Standards for School Mathematics (NCTM): <www.enc.org/online/NCTM/280dtoc1.html>
National Health Care Skill Standards: <www.fwl.org/nhcssp/health.htm>
National Printing Skill and Knowledge Standards: <www.gatf.lm.com/skills.html>
National Skill Standards for Electronics Technicians: <www.eia.org/cema/ps/res/nss.htm>
National Skill Standards for Hospitality and Tourism: <www.access.digex.net/~alliance/skills.html>
Photonics Education: <www.spie.org/photonics_ed.html>
SCANS Competencies: <www.stolaf.edu/other/extend/Resources/scans.html>

| Home Page | Selected Papers | Top of Page |

Last Update: August 18, 1999. *Contact:* Lynn A. Steen
URL: http://www.stolaf.edu/people/steen/Papers/work.html

SE063433

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Making Authentic Mathematics Work for All Students

Author(s):

Corporate Source:

Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY — sample — TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY — sample — TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY — sample — TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
1	2A	2B
Level 1	Level 2A	Level 2B
[✓]	[ ]	[ ]
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: Lynn A Steen

Printed Name/Position/Title: Lynn A. Steen

Organization/Address: St. Olaf College

Telephone: 507-646-3412

FAX: 507-646-3968

E-Mail Address: steen@stolaf.edu

Date: 05/18/00