

REAL-WORLD MATHEMATICS THROUGH SCIENCE: FACILITATING EQUITY IN MATHEMATICS

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Mathematics as well as math-based careers and professions continue to suffer from a lack of participation. The majority of students in the United States do not achieve their mathematics potential and are, therefore, unqualified to enter math- and science-based careers. In the recent past, it was thought that women and students of color "avoided" mathematics, that they chose not to participate in mathematics. There is considerable evidence that this is not the case, rather, the data show that there are inequities in the system that inhibit the full participation of women and students of color. Women and students of color do not receive the same opportunities to learn mathematics as do white males.

Real-World Mathematics Through Science is a series of middle school mathematics modules focused on learning mathematics by investigating a science context in which the mathematics is used. The modules are developed by teams of mathematics and science teachers working with scientists and engineers to design activities that facilitate mathematical and science connections between classroom and real-world mathematics and science. Scientists and engineers provide the basis for each module - the real-world uses of mathematics, and experienced classroom teachers provide the strategies for their successful use in the classroom. Each module, in concordance with the National Council of Teachers of Mathematics Standards, focuses on problem solving, mathematical communication, reasoning, and mathematical connections. Washington MESA initiated the project with funds from the National Science Foundation, and is continuing the development of new modules with funds from the Discuren Foundation. Addison-Wesley Innovative Learning Publications is publishing the modules. Eight modules are now in print, and two will be released in the Spring, 1997.

The *Real-World Mathematics Through Science* modules are designed to promote equity in the mathematics classroom. They specifically address those factors shown to inhibit mathematical growth in women and students of color by providing teachers with strategies and worthwhile tasks that will enable all students to develop their full potential in mathematics. *Measuring Earthquakes* provides experience for students to explore

exponents, plate tectonics, and seismology in the process of developing the Richter Scale. In *Packaging and the Environment*, students investigate surface area and volume in the process of developing efficient packaging designs. *Investigating Apples* gives students experience with box plots and sample surveys as they become familiar with the various facets of the apple industry. In *The Pharmacy* provides experiences in proportions and percents as students, playing the role of assistant pharmacists, fill real-life prescriptions. In *the Air* provides an opportunity for students to work with linear and angular measurement as they learn how pilots navigate. *Classifying Fingerprints* gives students experience in working with a binary number system as they learn how to take, analyze, and classify fingerprints. *Measuring Dinosaurs* provides experience with uncertainty and variation in measurement as students, using non-isometric scaling, estimate the size of dinosaurs for which complete skeletons have not been found. In *Secret Codes*, students gain experience with prime numbers and modular arithmetic as they explore the real-world of security codes. In *The Wind* extends the work begun in *In The Air*. Students explore the mathematics of navigating in the wind; they learn how pilots use vectors to compensate for wind and keep their plane on the intended course. *Designing Environments* provides experiences for students to learn how architects use ratios, proportions, and area as they balance costs, environmental concerns and aesthetics.

The presentation will include a review of those factors that inhibit equity in mathematics, discuss the recommendations to promote equity in the mathematics classroom, and demonstrate how *Real-World Mathematics Through Science* activities in addressing these factors, facilitate equity in the mathematics classroom. The models cover various science and mathematics topics, and discussion will focus on how the use of these materials will give middle school students a broad view of science- and math-based careers.

References

1. Curriculum and Evaluation Standards for School Mathematics. National Council of Teachers of Mathematics, Reston, VA, 1989.
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3. National Science Education Standards. National Academy Press, Washington, DC, 1996.
4. Beatriz Chu Clewell, Bernice Taylor Anderson, and Margaret E. Thorpe, Breaking the Barriers: Helping Female and Minority Students Succeed in Mathematics and Science. Jossey-Bass Publishers, San Francisco, CA, 1992.
5. Katherine Hanson, Teaching Mathematics Effectively and Equitably to Females. Eric Clearinghouse on Urban Education, July, 1992.
6. Separated by Sex: A Critical Look at Single-sex Education for Girls. American Association of University Educational Foundation, Washington, DC, 1998.
7. Jeannie Oakes, Lost Talent: The Underparticipation of Women, Minorities, and Disable Persons in Science. The Rand Corporation, Santa Monica, CA, 1990.

Factors Inhibiting Equity in Mathematics and Science

Pre-School Years

- **Lack of Exposure to Mathematics as Play**
Limits the opportunities to develop strong neurological pathways that are the foundation for the later abstraction of mathematics.
- **Girls Socialized to Be Passive**
Girls are socialized to respond quietly and not to initiate forced attention while boys are allowed to interrupt and encouraged to speak up.

Mathematics Content

- **Contrived Problems**
Simplified, trivial problems omit the ambiguities and real-world manifestations that motivate involvement.
- **Lack of Real-World Connections**
Students are deprived of contacts with role models and career information as well as worthwhile tasks.
- **Lack of Discussion and Writing in Mathematics**
The omission of verbal dialogue limits the cognitive strengths that low-esteem students bring to mathematics.

Mathematics Instruction

- **Rote Teaching**
Limits the opportunities to build the missing neurological pathways.
- **Competitive Learning Environment**
A competitive environment increases in low-esteem students the release of neurotransmitters that retard learning.
- **Lack of Collaborative Work**
Limits the opportunities for shared and nurturing experiences which release neurotransmitters that speed learning and increase self-esteem.
- **Lack of Hands-on Work**
Limits the opportunities to strengthen neural pathways and develop spatial constructs.
- **Lack of Sufficient Time-on-Task**
Time is needed to engage in the explorative work necessary to develop and strengthen concepts and self-directed approaches to problem-solving.
- **Styles of Discourse**
Lecturing limits opportunities for constructive learning and self-directed learning.

Mathematics Content and Instruction

- **Attitudes toward mathematics**
Math as a "Male Domain" is ingrained by second grade!
Girls, their parents, and their teachers still do not see math as useful for girls.
Lack of self confidence in mathematics is a learned response based in the early socialization of girls not to be risk-takers coupled with the social view that mathematics and technology involve risk-taking.

Single Sex Classes

- Limits girls opportunities to be risk-takers and gain self-confidence.

Recommendations to Facilitate Equity in Mathematics

Recommendations for Parents and Preschool Teachers

- Teach mathematics to young children through play to ensure the production of neurotransmitters that facilitate learning.
- Encourage active play that ensures strong neurological pathways necessary to the later development of higher-order skills.
- Make mathematics fun and exciting to ensure the development of positive attitudes toward mathematics.
- Prevent sex-role stereotyping by fostering the ability in girls to take risks, to be assertive, and to explore the environment.
- Assign chores equitably by rotating all chores among both boys and girls.
- Devise comfortable ways for girls and boys to play together in both active and quiet endeavors.

Classroom Recommendations for Content and Instruction

- Provide worthwhile, real-world problems that promote inquiry and problem solving.
- Incorporate role models and career information into these real-world mathematics problems, both in person and from a historical perspective.
- Engage students in hands-on work that encourages exploration and concept development.
- Encourage student directed exploration, rather than teacher directed work.
- Give students ample time to develop concepts and engage in inquiry and problem solving.
- Encourage collaborative, small group work focused on consensus, rather than competitive work focused on individual expertise.
- Include dialogue and writing as integral facets of an inquiry approach to mathematics.
- Include diverse perspectives on the historical development of mathematics.
- Create a supportive learning environment that minimizes stress, encourages risk-taking, and facilitates learning.
- Attend to attitudes toward mathematics as well as performance in mathematics.
- Nurture self confidence in mathematics as well as self esteem in general.
- Re-socialize girls to become more assertive and risk-taking. Praise them for self-initiated strategies, and provide them with the skills to become a public presence.
- Consider offering volunteer single-sex and co-ed classes in mathematics.

Recommendations for Parents and Preschool Teachers

- Examine own attitudes. Do we interact with students to encourage equity?
- Watch the words we use. Children do not interpret "man" to mean both "man" and "woman"!
- Raise gender issues to a conscious level. When we are aware of gender bias, we remedy it. The major problem today is unconscious gender bias.
- Do not ignore sexist, racist, homophobic, or violent interactions. Do not give tacit approval to such behavior.

Real-World Mathematics Through Science

In Concordance with NCTM Curriculum Standards

- Mathematics as Problem Solving
Pursuing open-ended and extended problem solving projects.
- Mathematics as Communication
Discussing, writing, and reading about mathematical ideas.
- Mathematics as Reasoning
Reasoning spatially, verbally, logically with proportions, tables, graphs.
- Mathematical Connections
Connecting topics within mathematics as well as to real-world mathematics.

In Concordance with NCTM Teaching Standards

- Worthwhile Mathematics Tasks
Activities focused on how mathematics is used in the real world.
- Orchestrated Discussions
Suggested discussion questions.
- Tools for Enhancing Discourse
Concrete materials, calculators and computers, small group work.
- Learning Environment
Focus on open-ended problem-solving with sufficient time allowances.

In Concordance with Classroom Recommendations for Equity in Mathematics

- Student Directed Work
Students work, group comes to consensus, then teacher orchestrates discussion.
- Hands-On Activities
Module introduced through concrete activity with ample time for exploration.
- Real-World Problems
Students pursue open-ended, real-world based problem solving.
- Collaborative Work
Small group work facilitates risk taking.
- Sufficient Time-On-Task
Students in small group work given time to develop concepts and strategies.
- Dialogue to Reach Consensus
Small group work focused on team approach to problem solving.
- Writing Assignments
Communication - reading, discussing, listening, and writing - is integral to activities.
- Supportive Environment
Students given time to succeed, with emphasis on working together which tends to minimize stress.
- Attitude Toward Mathematics
Non-competitive learning environment fosters mathematics for all students.
- Self Confidence
Non-competitive learning environment fosters self confidence and self esteem.
- Single Sex and Mixed Groups
Small groups can be varied to meet numerous needs.

**Real-World Mathematics Through Science Modules:
Washington MESA Middle School Curriculum Project**

Module Title	Mathematics Topic	Science Context	Career Link
In Print* In The Pharmacy	Ratios, Proportions & Percents	Solutions & Dilutions	Pharmacist
Measuring Earthquakes	Powers of Ten & Exponents	Earthquakes Plate Tectonics	Seismologist
Packaging & The Environment	Surface Area & Volume	Conservation & Waste Reduction	Packaging Engineer
Investigating Apples	Measurement & Statistics	Horticulture	Food Scientist
In The Air	Measurement & Functions	Navigation	Pilot
Classifying Fingerprints	Binary Number System	Forensics	Forensic Scientist
Measuring Dinosaurs	Measurement, Ratios & Scaling	Biology & Anthropology	Paleontologist
Secret Codes	Prime Numbers & Modular Arithmetic	Cryptology	Cryptographer
In The Wind	Vectors & Functions	Wind & Physics	Aeronautical Engineer
Designing Environments	Area & Perimeter	Ecology	Architect
In Development Designing Spaces	Surface Area & Volume	Environmental Science	Engineer
Wild Life Management	Probability & Statistics	Population Dynamics	Biologist

* Contract with Dale Seymour to publish Real-World Mathematics Through Science Modules