

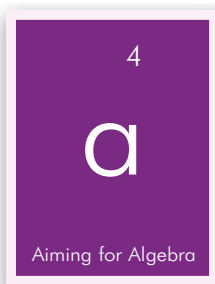
## CHAPTER FOUR · GIRLS AND THE MATH GAP

STEM—THE ACRONYM FOR SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS—PROFESSIONS HAVE BEEN AND WILL CONTINUE TO BE ENGINES OF U.S. ECONOMIC GROWTH AND NATIONAL SECURITY. THESE FIELDS HAVE BEEN STRUGGLING TO INCREASE THE PARTICIPATION OF WOMEN FOR DECADES. TO QUOTE WILLIAM A. WULF, PRESIDENT OF THE NATIONAL ACADEMY OF ENGINEERING, “WE NEED TO UNDERSTAND WHY IN A SOCIETY SO DEPENDENT ON TECHNOLOGY, A SOCIETY THAT BENEFITS SO RICHLY FROM THE RESULTS OF ENGINEERING, A SOCIETY THAT REWARDS ENGINEERS SO WELL, ENGINEERING ISN’T PERCEIVED AS A DESIRABLE PROFESSION . . . OUR PROFESSION IS DIMINISHED AND IMPOVERISHED BY A LACK OF DIVERSITY.” ALTHOUGH THIS QUOTE REFERRED SPECIFICALLY TO ENGINEERING, PROFESSIONALS IN ALL STEM FIELDS WOULD AGREE.

MATHEMATICS IS THE FUNDAMENTAL KEY THAT UNLOCKS THE DOOR TO THE OTHER STEM FIELDS. IT CONTAINS THE UNDERPINNINGS AND LANGUAGE OF TECHNOLOGICAL THINKING AND PROCESSES. CALCULUS WAS DEVELOPED TO DESCRIBE PHENOMENA IN THE PHYSICAL WORLD, INCLUDING THE MODERN-DAY TOPICS OF QUANTUM MECHANICS AND RELATIVITY. CHEMISTS USE COMPUTATIONAL METHODS TO PREDICT AND ANALYZE THE STRUCTURE OF COMPLEX MOLECULES SUCH AS PROTEINS AND DNA. MEDICAL RESEARCHERS USE STATISTICS AND PROBABILITY TO DETERMINE EFFECTIVE TREATMENT STRATEGIES AND PHARMACEUTICALS. ENGINEERS USE DIFFERENTIAL EQUATIONS IN THEIR ANALYSIS AND DESIGN ENDEAVORS TO MODEL RESPONSES OF STRUCTURES. CLOSING THE GENDER GAP IN MATHEMATICS IS AN ESSENTIAL FIRST STEP IN INCREASING THE PARTICIPATION OF WOMEN IN ALL THE STEM FIELDS. IN FACT, LITTLE SUBSTANTIVE PROGRESS CAN BE MADE—IN TERMS OF BOTH MOTIVATION AND SKILLS—UNLESS WE CAN BRIDGE THIS GAP.

THE PROJECTS DESCRIBED IN THIS CHAPTER ASPIRE TO NARROW THE GENDER GAP IN MATHEMATICS. TWO PROJECTS ADDRESS STRATEGIES TO ENHANCE GIRLS’ ABILITIES IN AREAS IMPORTANT FOR SUCCESS IN STEM AND WHERE GENDER DIFFERENCES PERSIST: MEASUREMENT ABILITY AND 3-D SPATIAL VISUALIZATION SKILLS. OTHER PROJECTS SEEK TO IMPROVE GIRLS’ MOTIVATION FOR STUDYING MATHEMATICS, WITH THE HOPE THAT THIS INCREASED MOTIVATION WILL EXTEND TO ALL STEM LEARNING. THE PROJECTS RANGE IN LEVEL FROM THE EARLY ELEMENTARY GRADES THROUGH HIGH SCHOOL. IMPROVING MATHEMATICS TEACHING METHODS TO INCLUDE STRATEGIES SUCH AS COLLABORATION AND REFLECTION, THE PREFERRED LEARNING STYLES OF GIRLS, IS ALSO BEING INVESTIGATED AS A MEANS OF ENHANCING MOTIVATION TO STUDY MATHEMATICS.

*SHERYL SORBY, PH.D., ASSOCIATE DEAN OF ENGINEERING, MICHIGAN TECHNOLOGICAL UNIVERSITY*



### AIMING FOR ALGEBRA

IN AUSTIN, TEXAS, A NONPROFIT CALLED GIRLSTART HAS DESIGNED AIMING FOR ALGEBRA, A PROJECT THAT PREPARES MIDDLE SCHOOL GIRLS TO COMPLETE ALGEBRA I IN EIGHTH GRADE. IF GIRLS CAN COMPLETE ALGEBRA I IN EIGHTH GRADE, THEY CAN THEN TAKE HIGH SCHOOL MATH AND SCIENCE CLASSES THAT LEAD THEM TO STEM MAJORS IN COLLEGE.

Aiming for Algebra has two broad components: a girls-only science and math club, and several community- and Internet-based math and science projects. Many of these activities involve girls' parents.

The objectives of the project, to take place over three years, are to

- Improve girls' confidence and academic self-esteem
- Increase girls' awareness of STEM careers and the high school and college coursework needed to enter such careers
- Enhance girls' knowledge of algebra and ability to use it in their lives.
- Improve parents' awareness of STEM careers for women
- Help parents encourage their daughters to succeed in algebra and subsequent math and science courses
- Help teachers raise girls' expectations of themselves in math and science classes
- Collect empirical data on how informal programming can help women

from groups underrepresented on the basis of ethnicity and race, income level, and language

Through Aiming for Algebra's cohort design and rigorous evaluation process, investigators can determine the effectiveness of specific interventions on girls' attitudes and skills. The program also includes a plan to make methodologies available to other interested communities.

GRADE LEVEL: MIDDLE SCHOOL	
GIRLSTART (TEXAS)	
RACHEL MUIR (RACHEL@GIRLSTART.ORG)	
HTTP://WWW.CLUBGIRLSTART.ORG/	02-17038
KEYWORDS: DEMONSTRATION PROJECT, SELF-CONFIDENCE, SELF-EFFICACY, ENGAGEMENT, MATH SKILLS, CAREER AWARENESS, CURRICULUM MATERIALS, BEST PRACTICES, ADVANCEMENT, ACHIEVEMENT, TRANSITION POINTS, EXTRACURRICULAR, CO-CURRICULAR, CURRICULUM TRAINING, TEACHER OUTREACH, LEARNING COMMUNITY, PEER GROUPS, STUDY GROUPS, CLUBS, PARENTAL INVOLVEMENT, ENGAGED LEARNING, PROJECT-BASED, ACTIVITY-BASED, COOPERATIVE LEARNING, COLLABORATIVE LEARNING, TEAMWORK APPROACH, MENTORING, DISSEMINATION PLAN, WEB SITE, SCHOOL-BASED, COMMUNITY-BASED, MINORITIES, UNDERPRIVILEGED, MATH, INFORMAL EDUCATION, TRANSITION POINTS, ALGEBRA, DATA COLLECTION, ASSESSMENT TOOLS	

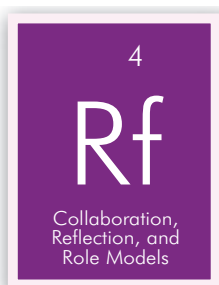
### EARLY INTERVENTIONS TO IMPROVE LATER MATH PERFORMANCE

THE UNIVERSITY OF GEORGIA IS TEAMING WITH THE UNIVERSITY OF MASSACHUSETTS-AMHERST TO EXAMINE WHETHER MATHEMATICS PERFORMANCE CAN BE IMPROVED BY A COMPUTER PROGRAM DESIGNED TO ENHANCE CHILDREN'S USE OF STRATEGIES IN SOLVING PROBLEMS AND FACILITY WITH NUMBERS ("COMPUTATIONAL FLUENCY"). THE STUDY ALSO TESTS WHETHER THE PROGRAM REDUCES OR ELIMINATES GENDER DIFFERENCES IN THESE AREAS. SUCH DIFFERENCES, WHEN DEVELOPED EARLY IN LIFE, HAVE BEEN SHOWN TO AFFECT MATH PERFORMANCE LATER ON.

Students in Georgia and Massachusetts will be randomly assigned to one of four experimental conditions. Investigators hope to determine whether focused instruction improves mathematics achievement, particularly for girls. If early intervention can ameliorate gender differences in math learning, changes in instruction might improve girls' ability to perform at higher levels of mathematics in early adulthood and increase their interest in the advanced study of STEM.



GRADE LEVEL: ELEMENTARY SCHOOL	
UNIVERSITY OF GEORGIA RESEARCH FOUNDATION, INC.	
MARTHA CARR (MCARR@COE.UGA.EDU)	
04-29088	
KEYWORDS: RESEARCH PROJECT, STRATEGY SKILLS, MATH SKILLS, GENDER DIFFERENCES, ACHIEVEMENT, LONGITUDINAL STUDY, COMPUTER-BASED TUTORING, MIXED-GENDER, MATH, CURRICULUM MATERIALS	



### COLLABORATION, REFLECTION, AND ROLE MODELS

TRADITIONAL MATH INSTRUCTION IN THE CLASSROOM OFTEN ASSUMES THAT LEARNERS WILL WORK ALONE AND ARE BEST MOTIVATED BY COMPETITION. GIRLS, HOWEVER, OFTEN LEARN BEST THROUGH COLLABORATIVE ACTIVITIES AND DIALOGUE. RESEARCHERS AT THE INFORMATION SCIENCES INSTITUTE, UNIVERSITY OF SOUTHERN CALIFORNIA, HYPOTHESIZE THAT GIRLS' MATH CONFIDENCE AND PERFORMANCE WILL IMPROVE IF MATH IS TAUGHT AS AN ACTIVITY IN WHICH STUDENTS HELP EACH OTHER CONSIDER VARIOUS APPROACHES TO PROBLEM SOLVING, AND HAVE FREQUENT OPPORTUNITIES TO ARTICULATE THEIR UNDERSTANDING OF MATHEMATICAL CONCEPTS.

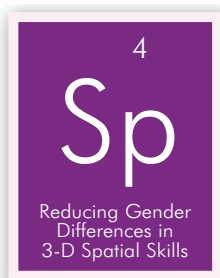
The project team has developed and tested two gender-inclusive features for Wayang Outpost (<http://www.wayangoutpost.net>), a Web-based intelligent tutoring system (ITS) for SAT math created with prior NSF support. (An ITS is a computer-based tutoring program that customizes instruction for each student.) With the “reflection” feature, students having difficulty with a math problem receive a prompt—“Why is this problem challenging to you?” for example, or “What insight is required to solve this problem?”—with space to write a response. This allows the student to describe the problem and to articulate the steps necessary to solve it, which helps to consolidate learning and make skills accessible for future problems. With the “chat” feature, a student having difficulty with a problem can request help from a fellow student who has already solved it; in this way, one student reinforces her knowledge by articulating it, while the other gets needed guidance and support.

Evaluation studies conducted in urban Los Angeles high schools reveal that students show significant improvement in their math problem solving after working with the Wayang Outpost tutoring system, as

indicated by pretest–posttest comparisons. Students who start with the weakest math skills show the greatest improvement and are most likely to use the multimedia help features in the ITS. Female students are most likely to use the chat feature and to report that it is a valuable tool for learning. In addition, female students show more interest than male peers in the identity of the chat partner and in learning math in the context of social connections. Current analyses examine gender differences in seeking help and the relative quality of dialogue within male–male, female–male, and female–female pairs.



GRADE LEVEL: HIGH SCHOOL	
INFORMATION SCIENCES INSTITUTE, UNIVERSITY OF SOUTHERN CALIFORNIA	
CAROL BEAL (CBEAL@ISI.EDU)	
<a href="http://www.wayangoutpost.net">HTTP://WWW.WAYANGOUTPOST.NET</a>	04-29125
KEYWORDS: RESEARCH PROJECT, SELF-CONFIDENCE, SKILLS, GENDER DIFFERENCES, GENDER DYNAMICS, TRANSITION POINTS, CO-CURRICULAR, ENGAGED LEARNING, COOPERATIVE LEARNING, COLLABORATIVE LEARNING, TEAMWORK APPROACH, ROLE MODELS, ELECTRONIC MENTORING, COMPUTER-BASED TUTORING, WEB SITE, ONLINE TUTORIALS, SCHOOL-BASED, MINORITIES, UNDERPRIVILEGED, SELF-CONFIDENCE, COMPUTER PROGRAMMING, SAT PREP COURSE, BIOINFORMATICS, COMPUTER SCIENCE, TECHNOLOGY, MATH SKILLS, CURRICULUM MATERIALS	



### REDUCING GENDER DIFFERENCES IN 3-D SPATIAL SKILLS

SPATIAL VISUALIZATION IS CONSIDERED TO BE ONE OF EIGHT HUMAN INTELLIGENCES AND HAS BEEN THE SUBJECT OF EDUCATIONAL RESEARCH OVER THE PAST HUNDRED YEARS. TWO DISTINCT THEMES HAVE EMERGED FROM THE RESEARCH:

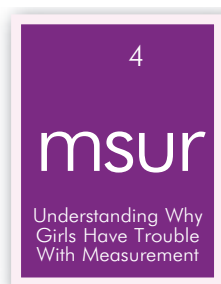
1. WELL-DEVELOPED 3-D SPATIAL SKILLS ARE CRITICAL TO SUCCESS IN STEM FIELDS.
2. THE 3-D SPATIAL SKILLS OF WOMEN TYPICALLY LAG BEHIND THOSE OF MEN.

In 1993, a course for the development of 3-D spatial skills was introduced at Michigan Technological University and has been continuously offered since that time. Each year, engineering students are administered a spatial skills test during orientation, and those who fail this test are counseled into the spatial course. Since spatial skills are critical to success in many introductory engineering courses, and since females are nearly three times more likely to fail the spatial-skills test than are males, participation in the course helps remove a barrier to success for women. Over the years, participation in this course has led to significant improvements in retaining female engineering students and higher grades in their follow-on engineering courses. In 1998, corresponding multimedia software and a workbook for developing 3-D spatial skills through self-paced learning were developed by the Michigan Tech team. These user-friendly, gender-neutral materials have been proven to be effective in developing the spatial skills of first-year engineering students

and similar improvements in retention and success in follow-on courses were observed. The current project will test these same materials with college students in other STEM fields and students at the middle and high school levels, paying particular attention to gender differences and preferred learning styles.

Principal Investigator Sheryl Sorby was awarded the 2005 Betty Vetter Research Award by the Women in Engineering Programs and Advocates Network for her outstanding research in 3-D spatial skills.

GRADE LEVEL: MIDDLE SCHOOL, HIGH SCHOOL, UNDERGRADUATE
MICHIGAN TECHNOLOGICAL UNIVERSITY
SHERYL SORBY (SHERYL@MTU.EDU)
04-29020
KEYWORDS: RESEARCH PROJECT, SPATIAL SKILLS, LONGITUDINAL STUDY, EXPERIENTIAL LEARNING, WORKBOOK, MULTIMEDIA SOFTWARE, ENGINEERING SKILLS, CURRICULUM MATERIALS



### UNDERSTANDING WHY GIRLS HAVE TROUBLE WITH MEASUREMENT

STUDIES OF STUDENTS' ACHIEVEMENT IN MATHEMATICS HAVE SHOWN THAT THE STRONGEST AND MOST CONSISTENT GENDER AND SOCIOECONOMIC STATUS DIFFERENCES ARE IN MEASUREMENT ABILITY, AN IMPORTANT PREREQUISITE FOR SUCCESS IN STEM FIELDS. BOSTON COLLEGE RESEARCHERS WILL INVESTIGATE THE BASIS FOR THESE DIFFERENCES AMONG FOURTH-GRADERS, WHEN CHILDREN BEGIN TO WORK WITH STANDARD MEASUREMENT TOOLS.

The study will advance in three phases. In the first, researchers will identify which specific aspects of measurement skill differ with gender and socioeconomic status, using a systematic and comprehensive test battery. Researchers will examine whether students' performance varies according to the task's cognitive demands—that is, students' performance on tasks that depend primarily on the knowledge of facts,

procedures, and numerical formulas will be compared with students' performance on tasks that depend on an understanding of measurement principles and spatial sense.

In the second phase, researchers will identify the factors that mediate gender and socioeconomic differences on the measurement test, specifically these differences in spatial or numerical skills (or both).

In the third phase, researchers will systematically vary procedures for introducing measurement concepts to girls and lower socioeconomic status students in particular. These systematic tests will provide stronger evidence of causality than correlation alone. The new measurement scales and the most effective teaching strategies will be made available online.

GRADE LEVEL: ELEMENTARY SCHOOL
BOSTON COLLEGE (MASSACHUSETTS)
BETH CASEY (CASEYB@BC.EDU)
05-22491
KEYWORDS: RESEARCH PROJECT, SKILLS, RESEARCH-BASED, SURVEY, UNDERPRIVILEGED, MATH, QUANTITATIVE SCIENCES, ASSESSMENT TOOLS, DATA COLLECTION, CURRICULUM MATERIALS, MATH SKILLS, GENDER DIFFERENCES



#### THE ROLE OF GENDER IN LANGUAGE USED

##### BY CHILDREN AND PARENTS WORKING ON MATHEMATICAL TASKS

RESEARCHERS AT THE CURRICULUM RESEARCH AND DEVELOPMENT GROUP OF THE UNIVERSITY OF HAWAII ARE INVESTIGATING GENDER-RELATED DIFFERENCES IN THE LANGUAGE AND BEHAVIORS OBSERVED AMONG THIRD- AND FOURTH-GRADE CHILDREN AND PARENTS WORKING TOGETHER ON MATHEMATICAL TASKS.

Each child–parent pair will be videotaped as they work on three mathematical tasks (number and operations, geometry, and algebraic reasoning) that have been developed to foster intense interactions between parent and child. The recordings will then be coded to identify gender-related differences in how parents and children communicate about the different areas of mathematics. Researchers will use a variety of investigative techniques, such as counting the number of conceptual questions asked and assessing the reliance on specific mathematical terms.

The theoretical framework for the study is based on prior research on the role of gender on children’s self-efficacy, parents’ competency beliefs for their children, and ways in which these affect cognitively demanding language. Data will be gathered on children’s self-efficacy and parents’ competency beliefs for their children to determine how these are related to the cognitively demanding language used by the four types of child–parent pairs: daughter–mother, son–mother, daughter–father, and son–father.

Following the study, investigators will develop recommendations for parents on how to talk about mathematics with their daughters in a way that encourages them to pursue academic study and careers in STEM.

Investigators believe that previous, related research was limited by assumptions that parents would be well-educated, middle-class professionals. Participants in this study are from underrepresented groups in STEM: those who are female, of diverse ethnicity, and of low socioeconomic status.

GRADE LEVEL: ELEMENTARY SCHOOL
UNIVERSITY OF HAWAII
JUDITH OLSON (JKOLSON@HAWAII.EDU)
05-22946
KEYWORDS: RESEARCH PROJECT, GENDER DIFFERENCES, PARENTAL INVOLVEMENT, ACTIVITY-BASED, MULTIGENERATIONAL, MINORITIES, UNDERPRIVILEGED, MIXED-GENDER, MATH SKILLS



