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Ch

Courses That Feed, Not Weed

CHAPTER THREE · COURSES THAT FEED, NOT WEED

THE WORLD NEEDS MORE SCIENTISTS AND ENGINEERS, AND IT NEEDS A CITIZENRY THAT UNDERSTANDS THE DISCOVERIES AND INVENTIONS THAT ARE CHANGING OUR LIVES. SCIENCE AND MATH COURSES NEED TO ENTICE, EXCITE, AND APPEAL, AS WELL AS INFORM OUR STUDENTS. THEY CANNOT BE BORING AND OUTDATED AND UNNECESSARILY HARD—AIMED AT "WEEDING" MOST STUDENTS OUT OF ADVANCED STUDIES. WE NEED TO ENGAGE AND INCLUDE MORE STUDENTS, AND A GREATER DIVERSITY OF STUDENTS, SO THAT THEY PERSIST FURTHER THAN BEFORE IN LEARNING THE BASICS OF SCIENCE, MATH, AND TECHNOLOGY.

THE PROJECTS IN THIS CHAPTER REVEAL MANY EXPERIMENTS IN COURSE DESIGN TO APPEAL TO A BROADER BASE OF STUDENTS, PARTICULARLY FEMALE STUDENTS. THE NEW COURSES ARE TESTED IN ACTUAL SCHOOL SETTINGS, AND THEIR EFFECTIVENESS IS EVALUATED. THE STORIES OF THESE PROJECTS SHOW A WIDE RANGE OF CREATIVITY IN BUILDING NONTRADITIONAL TEAMS TO DESIGN AND TEST NONTRADITIONAL APPROACHES.

SOME TRENDS IN THE LAST 10 YEARS ILLUSTRATED IN MANY OF THESE STORIES:

- THE INTRODUCTION OF STANDARDS FOR SCIENCE AND MATHEMATICS EDUCATION AND DEFINITIONS OF MINIMUM COMPETENCIES
- GREATER RELIANCE ON TESTING TO MEASURE LEARNING
- EMPHASIS ON TEAM PROBLEM-SOLVING IN THE CLASSROOM, WITH A MULTIDISCIPLINARY VIEW
- NEW CURRICULA INTEGRATING THE USE OF TECHNOLOGY, AND THE ARRIVAL OF DISTANCE EDUCATION USING TECHNOLOGY
- THE RISE OF THE "NONTRADITIONAL" STUDENT
- COMMUNITY COLLEGES' GREATER ROLE IN UNDERGRADUATE EDUCATION

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MATHEMATICS

003
ei
Early influences on gender differences in math achievement

EARLY INFLUENCES ON GENDER DIFFERENCES IN MATH ACHIEVEMENT

THIS THREE-YEAR LONGITUDINAL STUDY WILL EXAMINE *GENDER DIFFERENCES IN HOW FIVE FACTORS—SPATIAL SKILL, USE OF STRATEGY, SPEED OF RETRIEVAL, CONFIDENCE ABOUT MATH, AND CONCEPTUAL UNDERSTANDING—PREDICT MATH ACHIEVEMENT*. CHILDREN WILL BE ASSESSED EACH YEAR STARTING IN SECOND GRADE AND ENDING IN FOURTH GRADE. USING THE FIVE FACTORS AS PREDICTORS OF MATH ACHIEVEMENT, THE STUDY TEAM WILL BE ABLE TO SEE WHETHER SOME FACTORS INTERACT WITH EACH OTHER AS PREDICTORS OF MATH ACHIEVEMENT. DOES THE PRESENCE OF ONE FACTOR PROMOTE THE DEVELOPMENT OF THE OTHERS? DOES CONFIDENCE PROMOTE SPATIAL SKILLS AND THE USE OF STRATEGY, FOR EXAMPLE? DO EARLY SPATIAL SKILLS PROMOTE GREATER CONFIDENCE AND USE OF STRATEGY?

This project is studying the early elementary years because although gender differences in strategizing, spatial skills, and confidence have been documented in children of elementary school age, it is not clear how these differences may affect math achievement. If math achievement and conceptual understanding are affected by early emerging gender differences, is there a need to intervene in girls' math in the early elementary years rather than waiting until middle school and high school, when gender differences become more pronounced?

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HRD 01-14945 (one-year grant)	
Keywords: research study, gender differences, spatial skills, self-confidence, strategy skills	

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mmc
Math mega camp

MATH MEGA CAMP

A TWO-WEEK NONRESIDENTIAL SUMMER ENRICHMENT PROGRAM IN MATH AND SCIENCE, MEGA CAMP (MATH EXPLORATIONS FOR GIRLS ACHIEVEMENT) TARGETED SIXTH GRADE MINORITY GIRLS, BECAUSE MAJOR DECISIONS ABOUT WHETHER TO PURSUE MATH ARE MADE IN JUNIOR HIGH SCHOOL. HOSTED BY CALIFORNIA STATE UNIVERSITY AT HAYWARD (CSUH), THE CAMP WAS DESIGNED TO SHOW GIRLS HOW IMPORTANT AND USEFUL MATH SKILLS ARE AND TO EXPOSE THEM TO POSITIVE ROLE MODELS.

Sites for four field trips were chosen as much for motivational value as for educational content. Four cycles were built around the field trips, with introductory material before the trip and follow-up activities after. Each girl reported her discoveries and experiences on her page on the camp website.

At the Aerospace Encounter at NASA's Ames Research Center, students could design a commercial airliner on computers, complete a mission in a simulated space station, launch a "space probe" from a spinning chair, and more. In post-trip activities—including NASA's "planets made to scale" (a modeling activity) and a NASA lesson on charting the planets—girls explored really big numbers. At CSUH's Microscope and Graphic Imaging Center (MAGIC), they explored really small numbers, viewing various kinds of samples through different kinds of microscopes.

At Dreyer's Grand Ice Cream plant, they saw various phases of ice cream's manufacture, pondered such questions as why ice cream is sold in cylindrical cartons, and calculated how much of each ingredient was needed to make ice cream for a certain number of people. At the Technology Museum of Innovation, they could design and market their own bikes at a computer-assisted design station; study how robots see, hear, and move in the robot gallery; and see how the basic units of life are changed through gene splicing in the biotechnology station.

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www.mcs.csuhayward.edu/~mega/mc2001/mc2001.html	
HRD 98-10308 (one-year grant)	
Keywords: demonstration, summer camp, achievement, math skills, field trips, minorities, role models, website	

003

Sg

Single-gender math clubs

SINGLE-GENDER MATH CLUBS

WORKING WITH TEACHERS AND PUBLIC SCHOOLS IN BOSTON, LEXINGTON, THE BERKSHIRE HILLS, THE TECHNICAL EDUCATION RESEARCH CENTERS (TERC) DEVELOPED AND PILOTED SEVERAL SUCCESSFUL MODELS OF SCHOOL-BASED MATH CLUBS FOR ELEMENTARY SCHOOL GIRLS, INCLUDING

- Weekly math clubs for girls held during lunch or after school (boys who wished could attend).
- Single-gender girls' and boys' math clubs. Teachers paired up and traded students to form two single-gender groups. After completing a six-week unit of work, teachers traded groups so each teacher could experience both all-girls and all-boys groups. Most groups met once a week for an hour. One group met one week a month for five straight days.

In each school, the math clubs served as a framework within which teachers could learn about the gender dynamics in their classrooms. *They also used clubs as a low-risk place to experiment with reform math activities. After recognizing and reflecting on classroom gender issues in the math club framework, they could think about how to improve the coed classroom environment. Teachers at each site changed their regular classroom math instruction after experiencing their students' responses to reform math activities*.

The model clubs increased girls' enthusiasm for math, helped teachers improve the learning climate in their math classrooms, and increased community involvement in math education. Girls and boys participating in single-gender math clubs for 16 weeks scored significantly higher (an average 19.1 out of 22) on attitude surveys measuring confidence in math than students at the same grade level in the same schools who did not participate in the clubs (who averaged 16.0). Club participants also tested better on performance after 16 weeks of math clubs.

Girls said the clubs gave them safety from the put-downs they had come to expect from boys in discussions in the coed classrooms, more and better opportunities to participate, more fun socially, and better concentration (because the girls were calm and mature). Most participating girls and boys recommend single-sex math clubs to students in other schools—boys, because they could be with friends and could ask questions they wouldn't feel free to ask in a coed environment (such as "Are girls more mature than boys?" and "Is it true that boys are better at math than girls?").

Teachers who participated expected to continue the work in their communities. *Leading single-gender math clubs had made them aware of gender issues, including their biases toward boys in regular classrooms*. They asked themselves whether boys absorb most teacher attention because of discipline issues or because they are more assertive, whether teachers unknowingly communicate different expectations for boys and girls, and how to address the sometimes quiet culture of put-downs and harassment in many coed classrooms. *Because they traded students, facilitated the same math activities each club day, and met at common prep times, teachers began collaborating more and discussing pedagogical issues*. After hearing about the reform-based curriculum being tested in the math clubs, a number of teachers in other schools chose to experiment with it—and similar math clubs have appeared all over the country.

The experience improved the coed classrooms, where girls began to participate more and boys began to include girls more in class discussion and group work. The math clubs also provided a manageable structure for involving parents and business partners, who regularly visited math clubs to discuss the math they do in their work. Students and teachers learned more about the kind of math required for different careers and met successful women who used math in many different fields of work.

The project was well covered by the media—notably in a segment in a seven-part PBS television series, "Math: the Invisible Universe," which aired in 1998. Project materials included a presentation for parents called "Math Counts: Does Your Daughter?"

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Keywords: demonstration, self-confidence, teamwork approach, math skills, industry partners, school-based, role models, parental involvement, curriculum, engagement, PBS, TERC, Inc., gender equity awareness	

003

rfrm

Weaving gender equity into math reform

WEAVING GENDER EQUITY INTO MATH REFORM

OVER THREE YEARS, TERC AND THE UNIVERSITY OF CALIFORNIA AT SANTA BARBARA COLLABORATED WITH WELL-REGARDED STAFF DEVELOPMENT PROGRAMS FOR ELEMENTARY TEACHERS TO DEVELOP FOUR WORKSHOP SESSIONS FOR USE WITH ELEMENTARY TEACHERS, STAFF DEVELOPERS, SCHOOL AND DISTRICT ADMINISTRATORS, AND OTHERS CONCERNED ABOUT EDUCATIONAL EQUITY. EACH SESSION TACKLED AN AREA OF STANDARDS-BASED MATH (AS ARTICULATED BY THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS) THROUGH THE LENS OF GENDER EQUITY.

To incorporate equity into the most visible, well-attended math workshops in the country, this project linked key developers of elementary math curricula and staff development programs. These leaders and project staff came together for an intensive three-day working conference each year to develop four new workshops on equity and elementary math education. These workshop sessions can be integrated into extended in-service training or can be used as stand-alone sessions:

- *What Is Equity?*, an overview of equity in the context of standards-based math
- *Measuring Student Achievement: The Impact of Standardized Testing on Equity and Excellence in Mathematics*, on how state and national tests affect educational equity and on ways to help students prepare for standardized tests
- *Technology, Equity, and Mathematics*, on how computers can support children's math learning and on how to use computer resources equitably
- *The Home-School Connection*, on how parent/caregiver involvement can support in-school math learning

Collectively, the partnering math reform programs reach more than 13,600 elementary school teachers annually, teachers who want to transform their math curricula and pedagogical approaches. Teachers are enthusiastic about the reform curricula, which involve teachers as partners and insist they do math for themselves, understand how children learn math, and take on new roles in the classroom. A central premise of these curricula is that all students can do math, but this requires serious staff development.

As teachers become mathematically self-confident, they are going beyond arithmetic to incorporate strands on geometry, data, algebra, and the mathematics of change. They are learning to support discourse in their math classrooms, to encourage children to develop their own strategies for solving problems, to assess students' work in new and deeper ways, and to use technology to support children's understanding of math.

But the strand of gender equity, although honored as a concept, had not previously been incorporated in staff development workshops and leadership training. The unintended consequence was that few teachers participating in staff development understood that gender equity is essential to math reform. As student voices emerge, *if teachers aren't helped to build classroom cultures inclusive of all voices, the risk is great that assertive voices—all too often those of boys—will replace the previously dominating voice of the teacher*.

Many of the instructional strategies (cooperative learning, hands-on activities) embraced by these reform curricula have particular value for girls and for children of color, a fact rarely highlighted as a rationale for adopting these instructional approaches. Teachers need to know, in concrete ways, how they might change their practices to improve math learning for all students, but especially for girls. *Teachers have experimented with various ways of recording and reporting about games that allow a variety of players to share mathematical understanding. These strategies weren't developed to involve girls more in the number games, but teachers report that these adaptations have improved the quality of girls' engagement with the games and with the underlying mathematical thinking*. The communities involved in equity and in math reform have a great deal to offer each other.

Through this project, an equity component has been introduced into the teacher development work of the three major elementary-math curriculum projects funded by NSF (Investigations, Everyday Math, and Math Trailblazers). Gender equity is increasingly being incorporated in professional development workshops, models of equitable student–teacher interactions have been incorporated into the video training material of two major projects, and many educators have become familiar with the message that gender equity is essential to math education through the Weaving Gender Equity website and resource guide.

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Partners: University of California, Santa Barbara; UCSMP Everyday Learning Center; Mathematics Renaissance; Marilyn Burns' Math Solutions; the Developmental Studies Center's Number Power project; The University of Illinois at Chicago's Institute for Mathematics and Science Education Teaching Integrated Mathematics and Science (TIMS) project; Video Case Studies Project; California's SSI Math Renaissance Project; TERC's Investigations in Number, Data, and Space workshops; Eisenhower Regional Alliance for Mathematics and Science Education Reform; Eisenhower National Clearinghouse; Education Development Center (EDC); National Council of Supervisors of Mathematics (NCSM); Integrating Gender Equity and reform (InGear); Center for Research on Education, Diversity, and Excellence; Intercultural Development Research Association; and many others.		
Products: Four workshops, numerous articles, and a 70-page equity resource guide (available online at (www.terc.edu/wge/publications.html))		
Keywords: teacher training, gender equity awareness, workshops, TERC, Inc., math, curriculum, professional development, resource guide, website		

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Genderwise: exporting summermath

GENDERWISE: EXPORTING SUMMERMATH

SINCE 1982, THE INNOVATIVE SUMMERMATH HAS BEEN PREPARING A MULTIRACIAL GROUP OF HIGH SCHOOL GIRLS FOR THE REAL WORLD OF MATH. AFTER PARTICIPATING IN SUMMERMATH, GIRLS RETURN TO SCHOOL WITH MORE CONFIDENCE, INDEPENDENCE, AND PROBLEM SOLVING SKILLS. BY 1993 SUMMERMATH HAD BECOME A NATIONAL MODEL, ELICITING MANY REQUESTS FOR INFORMATION AND MATERIALS FROM EDUCATORS WISHING TO INCORPORATE ELEMENTS OF THE PROGRAM INTO THEIR CLASSES. THE GENDERWISE WORKING CONFERENCE WAS CREATED TO GIVE EDUCATORS A MEANINGFUL WAY TO VISIT SUMMERMATH AND UNDERSTAND ITS ESSENTIAL ELEMENTS—AND TO FACILITATE THE DEVELOPMENT AND IMPLEMENTATION OF NEW MATH INTERVENTION PROGRAMS MODELED AFTER IT. THE MAIN OBJECTIVE WAS TO PROVIDE A LIVELY, HANDS-ON ENVIRONMENT IN WHICH EDUCATORS COULD OBSERVE, EXPERIENCE, AND DISCUSS A PROGRAM DESIGNED EXPLICITLY FOR GIRLS TO LEARN MATH.

The 24 educators selected the first year spent five days at Mount Holyoke while the SummerMath program was in session. They were given a guided half-day experience with pair–problem solving, learned about gender equity issues, and shared experiences and reflections on what works for high school girls (and why), on problem-solving approaches, and on gender-related issues. A full day of observing SummerMath classes was followed by an in-depth discussion of perceptions and questions. Participants then began designing a project they could implement at their home institution. They all left with a copy of the SummerMath curriculum (more than 300 pages of problems, from fractions to precalculus) and with teachers' guides, the camp's Logo curriculum units, support materials for workshops they might hold at home, plans for an intervention project, and a network of colleagues.

During the six years they held the GenderWise conference, SummerMath hosted more than 100 educators from as far away as Alaska and Hawaii—several of them already leaders in bringing girls, minorities, and other underrepresented groups into math and science. Among the participants, for example, was a physicist and educator of the deaf (deaf himself) who brought two deaf staff members and eight deaf and hard-of-hearing girls to SummerMath 2001. GenderWise has widened the network of people committed to supporting young women's mathematical education.

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Chart on women's ways of knowing: www.scu.edu/SCU/Projects/NSFWorkshop99/html/morrow.html	
Keywords: demonstration, summer program, math, self-confidence, conference, intervention, hands-on, problem-solving skills, gender equity awareness	

003
Cg
Computer games for mathematical empowerment

COMPUTER GAMES FOR MATHEMATICAL EMPOWERMENT

POPULAR CULTURE OFFERS LITTLE OUT-OF-SCHOOL SUPPORT FOR CHILDREN'S MATHEMATICAL LEARNING—WITH THE POSSIBLE EXCEPTION OF COMPUTER GAMES, WHICH EXERT A TREMENDOUS PULL ON SOME CHILDREN. MANY GAMES PURPORT TO BE EDUCATIONAL, EVEN TO PROMOTE CHILDREN'S MATHEMATICAL LEARNING, BUT THERE IS LITTLE RESEARCH TO SUPPORT SUCH CLAIMS. RESEARCHERS ARE BEGINNING TO GET A HANDLE ON THE CONDITIONS UNDER WHICH STUDENTS LEARN MATH IN SCHOOL, BUT ALMOST NOTHING IS KNOWN ABOUT HOW COMPUTER GAME-PLAYING CAN SUPPORT AND EXTEND CHILDREN'S MATHEMATICAL KNOWLEDGE.

Researchers and software developers have also paid little attention to the disparities between boys' and girls' involvement with these games. Computer games *could* help increase all children's mathematical learning, but girls are not benefiting from their potential. For girls, the computer's screen is like a kind of glass wall: They can glimpse its worlds from a distance but are not invited inside. Hence this project's website name: "Through the glass wall: computer games for mathematical empowerment."

Through research with elementary and middle school students, this project seeks answers to three broad questions:

- How can children learn significant math from computer games?
- What characteristics of games, and of game-playing contexts, support learning?
- What patterns are there in girls' and boys' approaches to (and learning from) computer games?

In three studies, the project observed and interviewed children 7 to 13. Two studies examined how girls and boys in a summer computer camp used and learned from a variety of math-oriented computer games. One of the two looked at which games girls and boys chose to play and with whom they chose to play them; the other observed a group of girls playing a game designed for girls, focusing on how they collaborated and competed with one another. A third study, done with a small group of children in an after-school program, focused on how the children played a well-designed mathematical computer game and the kinds of mathematical thinking they developed over several months.

The project developed criteria for evaluating computer games for their mathematical potential, gender equity, and ability to engage children. Games that meet all three criteria are called MEGS (mathematical, equitable game software). The project website describes several dozen math-related computer games, provides reviews of many of the games, and gives lists of print and Web-based resources on gender equity, math, and computer games.

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HRD 95-55641 (three-year grant)	
Choosing mathematical game software: www.terc.edu/mathequity/gw/html/ChoosingSoftwarepaper.html	
Keywords: research study, gender differences, computer games, math skills, informal education, evaluation	

003
Aw
AnimalWatch: computer-based math tutor

ANIMALWATCH: COMPUTER-BASED MATH TUTOR

BECAUSE MANY GIRLS DISLIKE AND AVOID MATH, THEY ARE OFTEN UNDERPREPARED FOR COLLEGE SCIENCE AND ENGINEERING PROGRAMS. GIRLS' DECLINING CONFIDENCE IN THEIR OWN MATH COMPETENCE—ESPECIALLY FROM GRADES 5 THROUGH 8—IS PARTLY ATTRIBUTABLE TO THE TYPE OF INSTRUCTION AND FEEDBACK ON PERFORMANCE TEACHERS TYPICALLY PROVIDE, OR FAIL TO PROVIDE. *GIRLS ARE MORE LIKELY THAN BOYS TO BELIEVE THAT SUCCESS WITH MATH COMES FROM INNATE ABILITY, RATHER THAN EFFORT. IN THE TRADITIONAL CLASSROOM, TEACHERS TEND NOT TO "PUSH" GIRLS IF A PROBLEM CHALLENGES THEM, WHICH MAY IMPLY THEY ARE NOT SMART ENOUGH TO LEARN*. AND MOVING TOO SLOWLY THROUGH THE CURRICULUM MAY BE AS RISKY TO GIRLS' CONFIDENCE AS MOVING TOO QUICKLY.

This University of Massachusetts demonstration project uses the power of an intelligent computer-based tutoring system to help girls in grades 4–6 master math skills and gain in confidence and motivation—applying the intervention in late elementary school, when gender differences in attitudes toward math first become apparent. The software interface studies both boys' and girls' interactions. Research shows that *girls benefit from and appreciate*

- *Learning through exploration and collaboration*. Students, especially girls, respond positively to math software that does not rely on gender-stereotypic themes (such as storming a castle to save a princess), or competition with the self, another player, or the computer —characteristics prevalent in commercial math software (such as Math Blaster) that girls typically do not enjoy.
- *An interface and software environment responsive to girls and girls' interest in environmental biology*.
- *Feedback that builds confidence, sets high expectations, provides specific hints about how to overcome errors, and emphasizes appropriate effort, rather than native ability, as the key to math success*.

Combining educational psychology with computer science, this multidisciplinary research team deployed, evaluated, and continuously revised its supportive, adaptive, interactive math tutoring software in trials with hundreds of fourth, fifth, and sixth grade students in three school districts over several years. A teacher who noticed that girls enjoyed learning about endangered species suggested blending mathematical problem-solving with environmental biology. The software WhaleWatch was developed and then expanded to become AnimalWatch.

AnimalWatch uses a four-part narrative about endangered species—the right whale, the giant panda, and the Takhi wild horse (also known as the Przewalski wild horse)—as a context for solving word problems involving fractions, decimals, and percentages. The four-part narrative through which students progress was developed because students using an early version of the program said *they wanted more sense of progress as they worked, and girls do not respond well to the notion of competitive scoring*. Now, for example, a student who chooses the Takhi wild horse adventure begins working on problems about the species, then progresses to problems about Mongolia (the original home of the species), then moves to problems about preparing to go to Mongolia (fund raising, planning the trip, and packing), and finally takes a virtual trip to follow a group of horses being returned to the wild in Mongolia from a reserve in the Netherlands.

Word problems for all math operations are included for each part of the story. Templates now exist for more than a thousand word problems. When students complete one adventure, they can choose another and continue working on the same math level. Students work at their own pace and if they return for multiple sessions the tutor remembers where they left off so they do not have to go through the entire curriculum again.

Intelligent tutoring systems, unlike common drill-and-practice systems, modify themselves to conform to students' learning styles. When a student has trouble solving a problem, the software initiates a tutoring interaction that provides tailored hints and guidance to help the student work through the problem—using techniques from artificial intelligence to generate problems, select hints, and assess and model student preferences and abilities. A module called the "student model" creates a representation of each student's math understanding, selecting problems appropriate to the students' ability levels and responding to student errors with help and feedback tailored to their needs.

Although both boys and girls liked AnimalWatch, girls gave it a higher rating than boys did. Results of the first evaluation study show that WhaleWatch increased girls' self-confidence about math, raising it as high as the boys' self-confidence, even after working with challenging math problems. (The boys' confidence level, which started out higher, remained the same.)

Results of the second evaluation study (adding a control group that did drill-and-practice work with no feedback other than "correct" or "incorrect") were sometimes surprising: *Girls benefited from structured, interactive, concrete hints, examples, and adaptive feedback, whereas boys at the same level of cognitive development* lost *confidence when helped by the tutor* (perhaps feeling slowed down by the time taken by hinting—an argument for either reducing the hinting time or allowing students to turn it off). *Boys learned fastest when presented with demonstrations of algorithms and procedures*.

Male and female students ended up with similar levels of mastery but took different pathways—and the computer is able to adapt its instruction accordingly. Boys remained confident about math even with a drill-and-practice version of the system that responded to student errors with a simple "try again"; with the adaptive feedback turned off, girls were affected more negatively than boys.

Surprisingly, *the tutor was most helpful to students in the middle range of cognitive abilities*, as determined by a Piagetian pre-test. *Students with low cognitive abilities responded better to more concrete procedural hints, using interactive manipulables (such as Cuisenaire rods) that they could drag and drop. Students at the higher end of the cognitive scale preferred more abstract and symbolic hinting* (such as "Are you sure you are using the right operation?").

Even when there was no difference in problem-solving accuracy, girls and boys tended to approach problems differently. When students had to share a computer, girls showed a preference for working with other girls, and same-gender girls' pairs showed more genuine collaboration than mixed-gender pairs, but in terms of math confidence and objective problem-solving, girls also did well working with a male partner.

Finally, intelligent computer tutoring benefited students' math performance. Because AnimalWatch monitors the effectiveness of the help it provides, if a student continues to make errors after viewing one type of hint, the system will change to another type of hint. There was evidence that the software was providing effective instruction, in that *errors on subsequent problems were reduced after hints were presented*. Data are still being analyzed for the final evaluation study, but performance on a paper and pencil test were correlated with progress in AnimalWatch problem solving, and *working with AnimalWatch led to a reduction in errors on fractions problems on the paper and pencil math test*. Students also learned about endangered species.

Teachers often ignore instructional technology for fear that it won't teach the skills needed for standardized testing, so the team welcomed teacher input about math content. The tutoring system was deployed in many classrooms in three elementary school districts over the course of four years (with additional classes for use as controls in evaluation). Several regionwide in-service days helped 35 teachers incorporate the system into their curriculum. The website includes many resources for teachers, including a discussion feature and authoring tools that allow teachers to create their own word problems and even their own endangered species adventure.

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http://ccbit.cs.umass.edu/AnimalWatch	
HRD 95-55737 (one-year grant); HRD 97-14757 (three-year grant)	
The Animal Watch CD-ROM (suitable for ages 10 to 12) works on both Mac and Windows computers. It is available by request or can be downloaded from the website, but the download time may be prohibitive for most users.	
Keywords: demonstration, self-confidence, computer-based tutoring, math skills, intervention, exploration-based, teacher training, CD-ROM, software, research findings, interactive, gender differences, psychology, environmental biology	

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wrld

Animal world

ANIMAL WORLD

SOME NATIONAL ASSESSMENTS SHOW THE GENDER GAP IN MATH ACHIEVEMENT TO HAVE NARROWED DRAMATICALLY IN THE LAST DECADE, WITH SIGNIFICANTLY MORE HIGH SCHOOL WOMEN TAKING MATH COURSES. BUT OTHER DATA INDICATE THAT *GIRLS DO NOT CONFRONT THE CRITICAL TRANSITION FROM HIGH SCHOOL TO COLLEGE WITH THE DEEP, CONCEPTUALLY BASED MATHEMATICAL COMPETENCE THAT SUPPORTS ENTRY INTO STEM CAREERS. GIRLS PERFORM MUCH LESS WELL THAN BOYS, FOR EXAMPLE, ON COMPLEX PROBLEM SOLVING, WHEN THEY MUST APPLY NOVEL PROBLEM-SOLVING APPROACHES, AND WHEN THEY MUST WORK UNDER TIME PRESSURE OR TRANSFER SKILLS TO PROBLEMS THEY HAVEN'T SEEN BEFORE*.

Other research points to differences in male and female learning styles. Previous work by the project team indicates that, *on average, girls require more structured, concrete, and repetitive instruction where boys do equally well with more abstract hints and help, suggesting that they have a deeper understanding of math concepts*.

This project is designed to investigate characteristic male and female learning styles during the transition from high school to college as well as the factors that contribute to female students' shallower competence. These investigations will take place in the context of the Web-based multimedia simulation environment of Animal World: Wayang Outpost. Wayang Outpost provides high school women (and men) with

- An intelligent tutor for high school math (fractions, algebra, geometry, ratios/proportions/decimals, and probability) that provides gender-adaptive instruction, permits the analysis of male and female learning styles, and narrows the gender gap on the SAT math exam.
- A virtual mentor component, in which students who are solving math problems in the simulated world can meet real women who are researchers and experts, who discuss their training through video clips embedded in the simulation.
- A math-at-your-fingertips module in which students periodically rehearse math facts to free their cognitive resources for higher-order problem solving, predicting higher math test scores.
- A module to improve students' spatial cognition through dynamic manipulation of objects in simulated three-dimensional environments, which will permit a strong test of the hypothesis that girls' poorer math achievement reflects less well developed spatial cognition.

The project predicts that girls who work with the Wayang Outpost site will show significant increases in their skill at solving complex math problems, including their performance on the math SAT; that gender-adaptive instruction will foster greater conceptual understanding in female students; and that virtual mentors will encourage girls to report greater interest in STEM careers. The results should improve our understanding of male and female learning styles and produce new approaches to effective math instruction for all students.

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01-20809 (three-year grant)	
Keywords: research study, gender differences, computer-based tutoring, mentoring, SAT prep course, math skills, software, problem-solving skills	

003
got
Girls on Track: applying math to community problems

GIRLS ON TRACK: APPLYING MATH TO COMMUNITY PROBLEMS

UNDER A THREE-YEAR GRANT, NORTH CAROLINA STATE'S CENTER FOR RESEARCH IN MATHEMATICS AND SCIENCE EDUCATION ENGAGED 200 WAKE COUNTY MIDDLE SCHOOL GIRLS IN COMPUTER-BASED MATHEMATICAL INVESTIGATIONS OF COMMUNITY PROBLEMS TO HELP THEM DISCOVER THE ANSWER TO THE AGE-OLD QUESTIONS: WHAT GOOD IS MATH? WHY DO WE HAVE TO LEARN THIS STUFF AND WHEN ARE WE EVER GOING TO USE IT? THE GIRLS ON TRACK (GOT) MATH ENRICHMENT PROGRAM SHOWED MATH'S RELEVANCE TO THEIR LIVES AND IMPORTANCE FOR SOLVING COMMUNITY PROBLEMS. THE PROGRAM ALSO EXPLORED SOCIAL ISSUES RELEVANT TO RETAINING GIRLS IN MATH AND SCIENCES.

The centerpieces of their empirical work were teacher/counselor workshops and free summer camps for middle school girls who like math. Camp helped girls make the leap from arithmetic to algebraic thinking, a bridge many students have trouble crossing. Using computer technology, they explored patterns and functions, spatial reasoning, probability, and statistics. Algebraic concepts embedded in camp activities relied heavily on proportional reasoning (rational numbers, percentages, ratio and proportion, rate of change, slope), which is critical to success in Algebra 1 and beyond. Understanding covariance—how one variable changes in relation to another—is a conceptual leap required to engage in algebraic thinking. Engaging students in rate problems through "Virtual Vacation" activities, helped improve their skills in proportional reasoning. They also learned how to collect, organize, represent, and analyze data, find patterns and generalize, and present the results of their investigation.

To connect algebraic equations with the real world, the girls applied math concepts to community problems such as trash disposal, differences between men's and women's earnings, and whether there should be an HOV lane on I-40. When the topic was trash and recycling, teams of girls measured and weighed their personal and family trash for a week. To analyze the relative amounts of recyclables and decomposable trash, the girls did "action research," gathering data from the Web about the area's population, projected total trash output, potential versus actual recycling, and so on. They investigated problems the communities in Wake County might anticipate in the next 25 years, how fast the county's population is growing, and where the county should dump its trash. Counselors were careful not to burden the girls with their own opinions about these social problems—and to let them make observations on their own.

In a computer lab filled with networked laptops, the girls learned to use PowerPoint and Excel software for research and math exercises. They eagerly learned teamwork, investigative skills, and Web page design. By the second week, girls 11 to 13 were making PowerPoint slides with embedded Excel spreadsheets, animation, sound, and color—and were making team presentations to visiting dignitaries, demonstrating skills many adults lack.

Even daily games and sports algebra activities taught math concepts. In "blind volleyball," for example, they tossed a ball over partitions (a game that required constant scoring, counting, and mathematical analysis). Time was made during Math Moments and sports algebra to discuss the algebraic concepts imbedded in the activities.

Forty girls participated in 1999, 73 in 2000, and 69 in 2001, with some girls returning as junior counselors the following year. Winters, the girls were paired with math mentors. *There was a significant correlation between girls' scores on end-of-grade tests and their Year 1 scores on a Girls on Track test of proportional reasoning (r=79)*. Campers who took Algebra 1 in grades 7 and 8 got midyear grades of A or B. They were also more confident about their math and presentation skills and more positive about math and science. The longitudinal study is expected to yield information about why that trend shifts as girls mature.

To ensure that the professionals interacting with the girls were qualified in both technology and educational approaches, GoT brought together 50 Wake County algebra teachers, 25 guidance counselors, and 30 math-education undergraduates from North Carolina State and Meredith College, to develop year-round activities and summer programs. Very soon, teachers and counselors became proficient with the technology and incorporated sports algebra into their curriculum.

The program also explored some areas of technology development, including models to automatically recognize the level and depth to which a student understands a math or science topic (and models for predicting student achievement). *Early results from the project's work on an approach to computerized instruction called fault-tolerant teaching were promising. The FTT method groups questions into concepts in such a way that the concepts can be recovered from the questions and the questions can be recovered from the concepts. Their experiments showed that they can categorize test questions in concept categories based on student responses to questions and, from that information, can identify the concepts students appear not to understand. The FTT statistical approach is constructed to tolerate errors such as students answering a question correctly without knowing how, or accidentally missing a question they actually understood well*. FTT methods are being implemented in three NovaNET tutorals that will be administered to 100 math students (to be compared with a control group of 50 students). They expect to produce a *fully automated, fault-tolerant intelligent tutoring system*.

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Virtual Vacation activities and materials can be found at (http://ontrack.ncsu.edu/GoT/Materials/Vacation/) and (http://ontrack.ncsu.edu/Materials/index.html)	
Publication: S.B. Berenson, L.O. Cavey, and N.H. Smith, Girls on Track: Community Investigations and Fun with Math (NCSU, 2001).	
Keywords: demonstration, engagement, computer skills, exploration-based, sports-based, industry partners, research findings, teacher training, real-life applications, hands-on	

003

Gem

GEMS: exploring math through social sciences

GEMS: EXPLORING MATH THROUGH SOCIAL SCIENCES

THE DEMONSTRATION PROJECT GEMS (GIRLS EXPLORE MATHEMATICS THROUGH SOCIAL SCIENCE) ENCOMPASSES THREE PROGRAMS DESIGNED TO STRENGTHEN URBAN MIDDLE SCHOOL GIRLS' INTEREST, COMPETENCE, AND CONFIDENCE IN MATH BY ENGAGING THEIR NATURAL INTEREST IN SOCIAL ISSUES; IMPROVING THEIR TECHNICAL SKILLS AND INTERESTS BY BUILDING ON THEIR PREFERENCE FOR COLLABORATION AND CONNECTION; AND ENCOURAGING CONTACT WITH OLDER ROLE MODELS AND MENTORS.

A 10-week Saturday morning version of GO GIRL (gaining options: girls investigate real life) appropriate for urban girls features high-interest, hands-on math, social science, and computing experiences, collaboration, and intergenerational mentoring. This program will be offered in conjunction with Wayne State University in Detroit.

A Web-based version of the program SMART GIRL (surveys mathematics and research technology: girls investigate real life) will expand the capacity of a popular existing website (www.smartgirl.com) to teach girls how to gather and analyze survey data online.

The third program, UM-GIRL (using mathematics: girls investigate real life), was developed at the University of Michigan as a summer intervention program to engage girls in social science research and applied math activities. At both the University of Michigan and Wayne State University, student teachers in math and social studies will observe, train, and teach middle school girls on a small scale how to use computers and math tools to evaluate social science questions.

This project, which grows out of an NSF planning grant activity and an Eisenhower grant project, will yield an economical version of the GEMS curriculum, exportable to other institutions, and support material to help other cities implement the curriculum.

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Keywords: demonstration, urban, self-confidence, math, social science, role models, mentoring, hands-on, website, curriculum	

003
W
Womenwin: learning math through transactional writing

WOMENWIN: LEARNING MATH THROUGH TRANSACTIONAL WRITING

WOMEN TEND TO OUTPERFORM MEN ON MOST MEASURES OF RUDIMENTARY AND MIDLEVEL LITERACY; MEN, ESPECIALLY AT HIGHER LEVELS, TEND TO OUTPERFORM WOMEN IN MATH; *BUT GOOD WRITERS TEND TO DO BETTER IN MATH THAN POOR WRITERS*. IN THE WOMENWIN PROJECT, MATH AND ENGLISH PROFESSORS TEAMED UP TO TEACH MATH TO COLLEGE AND MIDDLE SCHOOL STUDENTS USING A TECHNIQUE CALLED *TRANSACTIONAL WRITING—A KIND OF PUBLIC WRITING THAT STUDENTS USE TO DEVELOP AND CONSTRUCT A CLEAR EXPRESSION OF THEIR MATHEMATICAL UNDERSTANDING*. WITH TRANSACTIONAL WRITING, WRITING BECOMES A TOOL TO LEARN.

In transactional writing, a math concept is broken down into its linguistic parts. For example, teachers who ask middle school students to add integers want both the sum and a written explanation of how they came up with the sum, on the principle that *if you can't explain something, you don't really understand it*. Students learn not only how to explain how they arrive at their answers, but also how to write and solve their own math word problems. They are graded on both their math and linguistic abilities.

Changing the emphasis from "calculating" to "understanding" represents a change in teaching and learning strategy. But alternative delivery strategies are needed in courses with consistently high student attrition such as college-prep math.

Participating in the three-year project were teams of math and English faculty from Miami–Dade Community College—a large urban two-year college—and their students, as well as three middle schools from Miami–Dade County's large urban public school system. The project used a quasi-experimental design with a nonrandomized control group (including pre- and post-tests). Participants were not randomly assigned to treatments, but four of eight college classes and nine of eighteen middle school classes from each school—selected at random each term/academic year—composed the experimental group; the other classes were the control group. The experimental and control groups were further separated by level and gender (females being the focus of the project).

The project examined whether transactional writing is useful both in constructing knowledge and in reshaping beliefs and attitudes about math.

The experimental groups received whole-class instruction, including transactional writing exercises. Using a split-page organizer, students responded to a math exercise on the left side of the page. The assigned mathematics investigator examined the writing exercises for content and accuracy; saw what was written, not what was meant; commented on any errors, omissions, and inconsistencies; and looked especially for failure to define terms, answer the question, or provide reasons.

Designated English and math faculty recorded their comments and suggestions on the right side of the page. Using the critiques and the split-page format, students had to submit a revision, which teachers commented upon and rated on a five-point scale. (To discourage late papers, one teacher placed incentive charts in her classroom. Having a sticker placed next to their name actually encouraged students to turn their papers in faster.)

Initially the project's middle school students were shy, bewildered, and frustrated, asking incessantly, "What do you want me to do?" Some flatly refused to write in their math classes. Slowly, very slowly, changes began to appear: less resistance, a marked increase in use of math terminology ("numerator" instead of "the top"), and, especially in abler students, more effort to write creatively. Those who had flatly refused to write began putting pen to paper.

Soon teachers observed that students in the writing groups were better prepared, more responsive and energetic, and had a better general attitude than those in the nonwriting group. Writers seemed to observe more, ask more, think and hypothesize more. They seemed better able to predict what would come next in the teaching and learning sequence. They were more likely to initiate discussions, especially those based on the draft-to-revision part of the writing cycle. *Through the writing assignments and the ensuing discussions, the instructor was better able to diagnose and remedy the most obscure of missing pieces, such as a student's inability to correctly plot points in a unit on graphing lines. Writing assignments revealed misconceptions that would not be picked up on more traditional assessment measures*.

Females and males participated equally, but, *although all students' math abilities improved, the most demonstrative changes were among female writers and male nonwriters. Writers were more likely to successfully complete their college coursework in one semester and, on both levels, writers scored higher on standardized measures of math achievement and attitudes toward math*.

Teachers outside the project were often perplexed about any possible correlation between mathematics and writing. *The project demonstrated that writing helped students understand relationships in math: If they could explain it, they understood it*. Both the math *and* the writing improved. *Writing reinforced and helped students retain their math skills*. Quiet females wrote and spoke more than they had before. Teachers observed an excitement about writing the draft, a desire for immediate feedback and positive reinforcement, and a definite improvement in self-esteem. Improvements came both academically and emotionally. Females who wrote were less likely to experience "math anxiety," and the stronger students could be more creative. Writing also allowed students to vent frustrations to which teachers were then better able to respond.

In middle schools, the courses ranged from sixth grade regular math to eighth grade gifted pre-algebra. The five community college classes ranged from college prep algebra to general college math. Over three years, this variety of courses, coupled with distinctly different learning and teaching environments and styles, provided ample opportunity to realize this intervention's value and flexibility. The project also contributed to research on the pairing of teachers and students for consecutive years. An incidental benefit to the project investigators was that networking online (because they could get in touch or post materials on their website virtually any time of the day or night) opened their eyes to the power of technology for teaching.

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Products: Training and curriculum materials, student writing samples, video	

Keywords: demonstration, self-confidence, transactional writing, math skills, community college, gender differences, English, intervention

003

Calc

Calculus research: animation and research portfolios

CALCULUS RESEARCH: ANIMATION AND RESEARCH PORTFOLIOS

SINCE 1987 THE NSF HAS FUNDED DOZENS OF PROJECTS TO REFORM THE TEACHING OF CALCULUS. FOR A WHILE, BOROUGH OF MANHATTAN COMMUNITY COLLEGE (BMCC) WAS THE ONLY TWO-YEAR COLLEGE TO RECEIVE NSF FUNDING FOR CALCULUS REFORM. AWARDED SEVEN GRANTS IN EIGHT YEARS, BMCC HAD BECOME A LEADER IN REFORM OUT OF CONCERN ABOUT LOW SUCCESS AND RETENTION RATES IN CALCULUS. BMCC WAS ESPECIALLY TROUBLED THAT ITS CALCULUS STUDENTS WERE ALMOST EXCLUSIVELY WHITE AND ASIAN AMERICAN MALES, IN A STUDENT POPULATION THAT WAS TWO THIRDS FEMALE (12,000 WOMEN) AND 85 PERCENT MINORITY.

Grant funding allowed BMCC to establish three state-of-the-art calculus computer labs; purchase calculators, graphing calculators, and laptops; send senior faculty to a weeklong workshop with Uri Treisman on collaborative learning; send key faculty to a two-week workshop at Dartmouth with John Kemenny on integrating computers into calculus, differential equations, and numerical analysis; run workshops for City University of New York faculty on the use of MAPLE (a computer algebra system), graphing calculators, and collaborative learning techniques; run two weeks of summer workshops for seven years, for hundreds of faculty from all over the country; conduct half-day workshops on computer use for adjunct faculty; and hire half-time college lab technicians and support staff.

BMCC's math department increased the number of minority students in the calculus sequence by emphasizing collaborative work on complex real-world problems, using appropriate technology; having students do research and make film animations of calculus problems and algorithms; and having them create portfolios of their best work. *Teams of students collaborated to "animate calculus"—to create animations of calculus problems, or "calculus movies." Students "learned to create" and "created to learn." BMCC's math department made mathematics a lively experimental science*. And calculus students learned math in the process. As part of their assessment, students produce "math movies," using computer software and the TI-92 graphing calculator to animate graphs. *Not only can they better visualize functions and series by animating these mathematical expressions but they are continually introduced to the unpredicted*.

With these innovations, *enrollment in Calculus III (BMCC's highest-level calculus course) increased from seven students in 1989 to 46 in 1996. But although reform helped attract and retain minority students, the department still struggled with women's enrollment*. Faculty training and

FLEXIBLE CALCULUS REFORM

The calculus reform begun in 1987 was a response to high failure rates—as many as 40 percent of undergraduates failing introductory calculus—*and the perception that rote learning produced students unable to apply math to complex or real-world problems*.

A reform approach to calculus often encourages students to

- *Work collaboratively in small groups on challenging real-world problems (following Uri Treisman's model)*
- *Do research*
- *Write and speak about their work*
- *Use appropriate technologies (such as computers and graphing calculators) to visualize and manipulate functions and families of functions*
- *Use computer algebra systems such as Maple to differentiate, integrate, and crunch data*

The program at Borough of Manhattan Community College *avoided the pitfalls of some reform projects that experienced backlash from traditional faculty members who longed for a return to the good old days of straight lecturing and textbooks that don't emphasize the use of technology*. The BMCC program adds labs, supervised by a laboratory technician, to the traditional classroom experience. Instructors are free to use as much or as little changed pedagogy as they feel comfortable learning. Some are totally committed to collaborative learning, even allowing some collaborative testing. Some insist on teaching classes in a lab (or with classroom-size amounts of graphing calculators) so the students can actually see graphs, rotate functions, etc., as the need arises in class discussion. Others have not changed their teaching style and rely on the lab to add the reform component. In the lab, students work together in groups on challenging problems. They learn to use a wide variety of software (Maple, Mathematica, Derive, True BASIC) and to write and speak about their projects.

the purchase of classroom-size quantities of graphing calculators and laptop computers allowed BMCC to extend the new, dynamic, interactive learning environment to *precalculus courses* (drawing women who show an interest in math) and statistics courses (drawing women in liberal arts and business majors).

BMCC learned from its highly successful women's portfolio project (HRD 97-10273) that *involvement in real research activities, supervised by an encouraging mentor, is the single most powerful catalyst for engaging women in mathematics. Trying on the persona of a mathematician—which includes doing research—is an important part of a mathematical scientist's education*. One student analyzed the mathematical principles involved in a series of children's games from her local area in Africa, for example, while a student in differential equations did a rigorous project on highway bridge construction.

Students were taught that a proper presentation of results, both written and oral, is a major part of research. One successful student completed an animation project on polar coordinates. Using MAPLE computer algebra software, she created moving images on the screen that showed how the graph changed as she changed variables in her equation. Asked by an evaluator to explain what she was doing, she responded, "What level of explanation do you want? Should I start by explaining what polar coordinates are? Do you want to know about the software that allows me to graph my equations? Would you like to know about the program I wrote that allows me to animate my equations? Do you want to hear what I am concluding based on my animations?" Her response made it clear that she was not just "learning" mathematics but was "doing" mathematics, as a working mathematician does. She went on to major in math at City College of New York.

Emphasizing student research projects and portfolios increased tenfold the number of students retained through Calculus III. And the ethnic make-up of students in BMCC's reform calculus program was now representative of the college as a whole. Although the college was less successful in breaking down gender barriers, it *more than doubled the number of women taking the courses necessary for a career in the mathematical sciences*.

A recent project (HRD 99-08658, *women's animated research in mathematics*) extends the work on women's research portfolios. It *is using successful strategies of calculus reform as well as learning strategies that have successfully changed math for undergraduate women (for example, tracking and respecting different participation styles, stressing the social aspects of learning, and providing role models and mentors)*. It is providing summer and academic-year fellowships for women in mathematical research and two-week workshops on such topics as how to do analytical graphing on the Macintosh, how to create animations on the TI-92, how to solve problems using Maple and Mathematica, and how to give oral and panel presentations. As the BMCC faculty has learned, however, *it is working one on one with senior faculty who respect their ideas that will help these women grow*.

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Keywords: education program, calculus, math, community college, teacher training, collaborative learning, research experience, animations, mentoring, fellowships, minorities

003

Path

Pathways through calculus

PATHWAYS THROUGH CALCULUS

YOUNG WOMEN (ESPECIALLY MINORITY WOMEN) PREPARED FOR COLLEGE BUT DEFICIENT IN MATH WERE GIVEN A CHANCE IN 1993 TO PARTICIPATE IN TWO INTENSIVE FOUR-WEEK SUMMER INSTITUTES TO SHOW THEM THEY COULD EXCEL IN MATH AND TO STRENGTHEN THEIR CHANCE OF SUCCESS. BASED ON AN HONORS CURRICULUM, THE FIVE AND A HALF HOURS OF DAILY CLASSROOM ACTIVITIES WERE DEDICATED TO EXPLORATION AND REAL-WORLD APPLICATIONS OF PRECALCULUS AND CALCULUS. THE WORK WAS DESIGNED TO STRENGTHEN PARTICIPANTS' MATHEMATICAL POWER, KEEP THEM IN COLLEGE, CHANGE THEIR COURSE PATTERNS IN MATH, AND REDIRECT THEM TOWARD STUDY AND CAREERS IN MATH AND THE PHYSICAL SCIENCES. CALIFORNIA STATE UNIVERSITY AT FULLERTON HOSTED THE INSTITUTE.

Each of 34 participants was given a TI-82 graphing calculator and used it extensively, especially for analyzing function behavior. Working in groups of three, and using the text *Contemporary Precalculus Through Applications*, the students covered data analysis, functions, polynomials, rational functions, algorithms, exponential and logarithmic functions, trigonometry, and matrices. They were given a pre-test, four quizzes, and a post-test and directed to enroll in the appropriate math course and supporting workshop for the fall semester. Students were paid a stipend of $400 and given books and supplies, room and board. They lived in campus dorms but spent weekends at home.

The next summer 35 students, each of whom had completed at least one semester of calculus, participated in Pathways Through Calculus. Participants at the second institute included both returning students and new students, some of them junior college transfers. Each student was given a TI-82 graphing calculator and investigated iteration, chaos, fractals, and the elliptic orbits of planets, using as a primary source *Student Research Projects in Calculus*.

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Keywords: demonstration, calculus, math, summer program, exploration-based, real-life applications, career awareness, physical sciences, graphing calculator, research experience	

Through projects, they improved their critical thinking skills, learned how to apply multiple skills and technology to one problem, and began to overcome fear of word problems. They worked on projects such as why astronomers use telescopes with parabolic mirrors, preparing for the census, solving systems of linear equations, finding the area of your hand, exploring uncharted waters, and finding the zero of a polynomial. Because of the extended nature of the work, many learned how to work effectively in groups.

003

E-w

E-WOMS: women's ways of learning calculus

E-WOMS: WOMEN'S WAYS OF LEARNING CALCULUS

GIVEN THE RIGHT CLIMATE, WOMEN ARE AS CAPABLE IN MATH AS MEN, BUT AS FEW AS 5 PERCENT OF THE WOMEN WHO TAKE CALCULUS I GO ON TO TAKE MORE COLLEGE MATH. NORTHERN ILLINOIS UNIVERSITY'S E-WOMS PROJECT (EXPANDING WOMEN'S OPPORTUNITIES THROUGH MATHEMATICAL SCIENCE) FOUGHT STEREOTYPES AND CHANGED NIU'S APPROACH TO MATH EDUCATION. EMPHASIZING THAT *SCIENTIFIC LITERACY IS MORE THAN A WOMEN'S ISSUE*, IT USED ADS TO ALTER CAMPUS MISPERCEPTIONS ABOUT WOMEN'S MATH ABILITIES. IT ALSO OFFERED A *CALCULUS I COURSE GEARED TOWARD THE WAYS WOMEN LEARN—WHICH EMPHASIZED COLLABORATIVE PROBLEM SOLVING IN A LEARNING COMMUNITY, RELATED CALCULUS TO REAL LIFE, REQUIRED STUDENTS TO WRITE ABOUT HOW THEY APPROACH PROBLEMS, AND MADE USE OF MENTORS AND SUPPORT GROUPS.*

One aim of the program was to help women pass Calculus I, a barrier course and falling-off point for women. All freshmen passing a math placement test at A-level qualified to take the course and were also admitted to a well-publicized *focused interest group* (FIG) for women in math. Thirteen women self-selected or were placed in the pilot program by college advisers.

The grant staff was chiefly female, but male professors were given a chance to work with the FIG students, because *research suggests that whether women students succeed academically depends more on the instructors' accessibility and teaching techniques than on their gender*. Richard Blecksmith, one of the department's most talented calculus professors, was course instructor for the intervention section.

Blecksmith drew on *research about women's ways of learning* to develop appropriate teaching strategies for the course. *The curriculum humanized math by presenting math concepts and problems in contexts that connected with students' interests, experiences, and relationships*. For example, problem-solving used real-life applications to topics such as wildlife extinction rates and the populations of endangered species, world population growth, the spread of infectious disease, and the rate at which drugs are absorbed into the bloodstream.

Blecksmith listened, and the students talked, more than in a traditional classroom, because women *like to talk through and verbalize problems, rather than being left alone to solve them*. Through the inquiry approach to learning, the teacher guided students through a process of *discovering math concepts for themselves, so that math made sense to them. The learning environment was less competitive and more collaborative than in traditional calculus classes*.

Students discussed how they solved problems and wrote narratives describing how and why they used certain problem-solving strategies, narratives that included both explanations and mathematical computations. They got feedback from each other and from the teacher. They were asked to write about current statistics or polls in the newspaper, to show their understanding of course principles. The instructor used both traditional and alternative forms of assessment, such as journals and self-critiques—and students were asked to critique the course and text at important junctures. Students learned math in a way that convinced them they could and did understand the subject.

To help create a learning community—a support network of peers—the same students were also enrolled in an extended version of a campus orientation course, one that addressed issues pertinent to women. The instructor—a doctoral candidate in math—served as mentor for the women, along with the calculus instructor and the project's principal investigators.

The pilot class met for an extra hour of mentoring each week. Instead of using the extra time to work through calculus equations, students participated in other math-related activities, such as reading the Tony Award–winning play *Proof* (about a woman mathematician) and meeting notable women who spoke on campus—including astronaut Mae Jamison. Many of NIU's students come from *rural communities in which there are few, if any, female role models in careers involving math and higher education*.

Part of the goal was *to see what would happen to women if there were no competition from men in the class*. Blecksmith was surprised by the program's across-the-board success. "I thought we'd be successful," he said, "but not to this extent, to tell the truth. I've never had a calculus class outside of honors where everyone has passed the course with a C or better." *Even though the course and exams were more rigorous than usual—almost to the level of an honors course—test scores were 20 percent higher than they had been the year before and the students had a better grasp of the concepts than any class he had seen in a long time. Many of the women expressed disappointment with their test results, although their grades were higher than average for Calculus 1*.

Research shows that *many women in college will change their majors to avoid taking additional math classes, if they don't find peer support for taking math. None of the women in the FIG did so. Before the intervention, only one or two women usually took Calculus II, but 10 of the 13 students in the pilot project took the regular Calculus II course the next fall, staying together at their own request*. Women made up half the Calculus II class the next year, and women from the FIG got the highest scores on the first exam.

AD BLITZ TO DISPEL STEREOTYPES

NIU's departments of communications and math sciences and the women's studies program collaborated on ads to reverse negative misperceptions about women's abilities in math. Graduate interns in communications designed a campus ad campaign around the slogan "Women Succeed in Math." The social-norms ad blitz was patterned after NIU's nationally recognized social-norms program to curb alcohol consumption among students. The ads appeared in the campus paper once a week or more (usually on Mondays, the heaviest circulation day) and as posters in prominent spots around campus. The first ad stated that 15 percent of the men—and 20 percent of the women—who had completed Calculus I from 1995 through 1999 had earned an A. Another ad asked which of the following was a woman: the head of Hewlett–Packard, the CEO of eBay technologies, the president of the Mathematical Association of America, the inventor of the computer language Cobol, or (the correct answer) "all of the above."

The support/study group, which continued to meet weekly the next year, was an important factor in the project's success and the women's commitment to helping the entire group succeed in math. And several other study groups formed and students unused to collaborative studying began faring better on math tests.

Men can also benefit from classroom and support interventions, but research indicates that the learning environment is especially important for women, who come into the university system not understanding how important math is to their careers and less likely than men to pursue coursework in advanced math. Those who advise women students could play an important role in encouraging more women to take math instead of automatically routing them into humanities and English courses. In this project, positive reinforcement changed the numbers.

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www.clas.niu.edu/wstudies
www.clas.niu.edu/wstudies/pdfs (social-norm ads)

HRD 00-86310 (three-year grant)

Keywords: demonstration, math, calculus, collaborative learning, problem-solving skills, real-life applications, mentoring, support system, inquiry-based, peer groups, field trips, role models, self-confidence, intervention

003

Qs

Recruiting women in the quantitative sciences

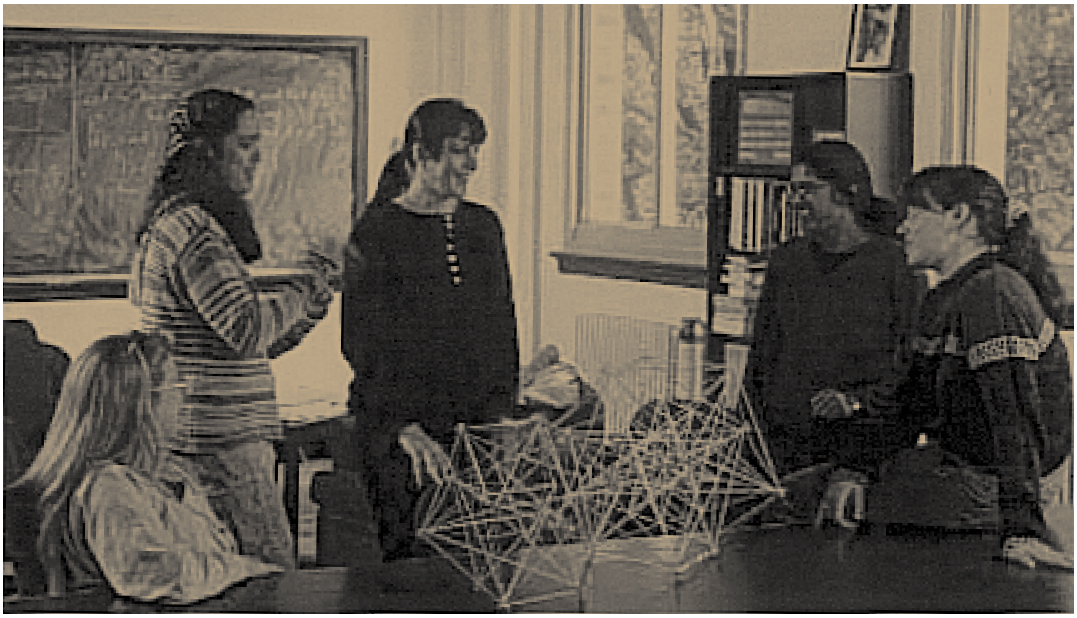
RECRUITING WOMEN IN THE QUANTITATIVE SCIENCES

IMPROVING THE INSTITUTIONAL CLIMATE FOR WOMEN IN SCIENCE REQUIRES ENABLING WOMEN TO DEVELOP ENOUGH RESILIENCE AND ADAPTABILITY TO OVERCOME THE STRESSES INHERENT IN (WOMEN, ESPECIALLY) PURSUING A CAREER IN SCIENCE. WITH PROJECT ADVANCE, DUKE UNIVERSITY AIMED TO RECRUIT A RESILIENT COHORT OF TALENTED FIRST-YEAR WOMEN STUDENTS INTERESTED IN, AND IDENTIFIED WITH, THE QUANTITATIVE SCIENCES—ESPECIALLY MATH, STATISTICS, AND COMPUTER SCIENCE, IN WHICH WOMEN'S PARTICIPATION IS DISMALLY LOW.

The centerpiece of the ADVANCE program has been a model interdisciplinary course, Perspectives on Science. The half-credit course, which meets for two hours once a week, introduces students to a cadre of dynamic women Ph.D.'s in scientific careers, fosters a greater sense of self- and group identity, and showcases research and applications of the quantitative sciences in the light of current research and technology efforts in interdisciplinary science.

In the fall, the course deals with applications in the biological, medical, and environmental sciences. Local and nationally prominent women in science and math come to speak on such topics as chaos and the spread of disease, pesticide exposure in preschool children, string theory and life with five children, and how to mathematically model the optimal decision process for employment, medical care, and insurance. For the spring course—emphasizing engineering and the physical and social sciences—speakers address such topics as conservation laws and traffic flow. Graduate student panels encourage student identification with the speakers.

Duke's curriculum underscores the centrality of writing in all undergraduate work, and the university writing program mandates a first-year writing course: Academic Writing 20. Over two years, ADVANCE students took specially designed sections of Writing 20 to develop skills in scientific writing and analysis: Cooperation, Competition, and Interpretation; Representing Disease; Reading and Writing Science; or The Science Behind Controversy.



A section on Cooperation, Competition, and Interpretation, for example, explored a controversial theory in evolutionary biology, microbiologist Lynn Margulis's theory of evolution by symbiosis, which challenges the primacy of natural selection and the basic paradigm of neo-Darwinism. In short exercises and four draft papers, students sought first to understand traditional Darwinist evolutionary biology and then to interpret and evaluate Margulis's challenges to neo-Darwinist orthodoxy. Students examined such issues as the bias in evolutionary biology toward complex organisms; the challenge Margulis poses to the concept of the "individual" organism; the implications of making cooperation, rather than competition, a major image of evolutionary change; and the effect these conflicting images of biological evolution have on concepts drawn from evolutionary thought (such as *progress and growth*). Working in groups, students discussed and developed ideas, advising each other, reviewing each other's work, and revising drafts. They learned both to write better and how controversies emerge within scientific disciplines.

The writing course and a series of discipline-based seminars echo the theme of the emerging and interdisciplinary nature of science, the variety of its applications, and science's links to society. The idea is that if math doesn't seem to most students to have practical applications, the facts will seem more relevant and alive if emphasis is placed on the process of discovering ideas and the people who discovered them.

ADVANCE also offered discipline-based first-year seminars in 2000–2002, including Artificial Intelligence and Automated Reasoning. Over two years, eight ADVANCE students participated in Duke's summer research fellows program.

Over 60 percent of the 2001–02 participants have declared a major in the sciences, including four math majors, two math/biology majors, and a computer science major. Five other ADVANCE students have chosen science minors, and two nonscience majors are pursuing pre-med studies. The two graduate coordinators are pursuing doctoral degrees in math and physics, and *Duke has begun recruiting more women faculty in the sciences*.

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HRD 99-79478 (one-year grant)	
Keywords: demonstration, quantitative sciences, math, statistics, computer science, curriculum, writing, seminars, recruitment	

ENGINEERING

003

IP

Imagination place

IMAGINATION PLACE

EDC'S CENTER FOR CHILDREN AND TECHNOLOGY DEVELOPED AN INTERACTIVE ONLINE DESIGN SPACE, *INVITING GIRLS 8 TO 14 TO THINK AND ACT AS TECHNOLOGY DESIGNERS, NOT JUST USERS. IMAGINATION PLACE* ENGAGES CHILDREN IN A DESIGN PROCESS THAT INVOLVES IDENTIFYING A NEED, PROBLEM, OR OPPORTUNITY; COMING UP WITH AN IDEA TO MEET THAT NEED; UNDERSTANDING AND SELECTING DESIGN OPTIONS; AND MAKING A DESIGN IDEA A REALITY. ENGAGING GIRLS IN *COLLABORATIVE DESIGN PROVIDES A POWERFUL PATHWAY TO THE WORLD OF ENGINEERING, GIVING THEM NEW WAYS TO SEE AND THINK ABOUT TECHNOLOGY'S IMPORTANCE IN THEIR LIVES*.

EDC is developing the interactive online environment in partnership with Australian Children's Television Foundation (ACTF, creators of KaHootZ interactive software) and with Libraries for the Future (whose agenda is to promote libraries as learning environments, especially to low-income communities and to girls and women, the main users of public libraries).

To research children's conceptions of the Internet, the project asked 30 children to create something to explain what the Internet is to someone who doesn't know. Nearly half the boys described features of navigating and getting on the Internet rather than the functions one can perform. Girls tended to describe its functions as a tool for connection and communication ("it connects people to games and other people"). Creating *an environment that provides a sense of place and community with useful multipurpose tools is more important for engaging girls than the games targeted mainly to boys. Communication and discussion* should be an entry point to the design area. Children also need *guidance in using search engines to answer specific questions*.

When the children were asked to create a fantasy device to their own liking, to name it, and to describe its performance, *girls' inventions were often designed to solve human, health, or performance-related problems* (falling asleep, carrying things home, helping shoot baskets perfectly). Their inventions tended to highlight portability and multiple functions, which they tended to illustrate in a storyboard manner. Boys tended to create computer-related inventions and to focus on their machines' features rather than functions. *Girls were less likely than boys to focus on the parts of their machines in relationship to the whole, so the project stressed games that would stimulate girls to do so*.

By testing ten activities at two sites, the project found *that learning about design carried over from one activity to another, but that children were not experienced at using the computer to draw and create designs. They need explicit instructions and time to experiment with the drawing tools before being able to complete certain activities with minimal frustration*. Timing is crucial: kids are accustomed to working offline for 30 minutes and then on the computer for 30 minutes. And when asked to think about marketing their inventions, *students rarely connect the cost of materials to create an object* to the cost of the final object. Crucial tasks for the project are to *strike the right balance between discussion and computer-based activities and between ease of entry into activities and intellectually challenging content*.

The project learned other important lessons from the final field test, conducted with about 200 students in informal and informal U.S. and Australian settings. First, *design club leaders hosting clubs in libraries and informal settings need additional support to understand how to help girls express their technological ideas and to think about how systems in machines work*. Nearly all leaders reported that their *children had begun to think of themselves as designers and inventors as a result of participating in Imagination Place clubs—a significant first step toward girls participating more fully in technology*.

They also learned that *sharing work online and having an authentic audience for their work is a big motivator for girls creating their own investigations, but this requires that design club leaders help the girls prepare for online discussions of their work by viewing their peers' inventions before chatting and by drafting a set of critical questions to ask*. Participants who had fewer technical resources spent more time doing start-up activities about design and technology, which altered the depth of work students did online.

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Partners: Australian Children's Television Foundation; Libraries for the Future	
Products: Poster, resource guide	
Keywords: demonstration, interactive, website, mentoring, engineering, EDC, design-based, research findings, engagement, educational games, television, underprivileged	

003

EE

Exploring engineering

EXPLORING ENGINEERING

THIS MOTIVATIONAL PROGRAM FOR EIGHTH GRADE GIRLS—ESPECIALLY GIFTED GIRLS FROM POOR OR MINORITY FAMILIES, WHO TYPICALLY DO NOT SEE THE IMPORTANCE OF PREPARING FOR HIGH-SKILL, HIGH-WAGE CAREERS—BROUGHT TOGETHER EDUCATORS, PRACTICING ENGINEERS, AND OTHER PARTNERS TO TEACH THE GIRLS, THEIR PARENTS, AND THEIR MIDDLE SCHOOL TEACHERS ABOUT OPPORTUNITIES IN MATH, SCIENCE, AND ENGINEERING. SEVENTY MIDDLE SCHOOL TEACHERS RECEIVED TRAINING IN BIAS-FREE TEACHING, INSTRUCTIONAL METHODS FOR BUILDING MATH AND SCIENCE SKILLS, AND STRATEGIES FOR INVENTION AND EDUCATION WITH GIFTED GIRLS.

Activities for the girls involved mentoring, enrichment activities, and career-related experiences. Over two years, about 250 girls and their parents participated in such activities as

- Explorathon, AZ, hands-on workshops to show 100 girls that science is not forbidding. These workshops, coordinated by Arizona State University and the American Association of University Women, were conducted by professional women in STEM. In a simple introduction to aerodynamics, for example, they made paper helicopters (spinning rotor blades made from a single piece of paper and dropped from a height), varying the geometry to make the blades spin or fall faster or more slowly. Activities were designed for the girls to experience success.
- Career and high school exploration, math and science teachers telling eighth grade girls and their parents (200 in all) about high school courses, expectations, and opportunities.
- Engineering exploration, an all-day Saturday event at which the Society of Women Engineers presented demonstrations and talked about their engineering experience. Lunch for girls and their parent or teacher was complimentary and transportation was available, so low-income and minority students could participate. Over two years, 116 girls attended.

Girls also visited local institutions of higher learning, sat in on classes at the high school of their choice, and toured local industries such as the Boeing Company, Motorola, Allied Signal, and a Phoenix hospital. Some entered engineering-based competitions (Future Cities, Sounds of Mars, and the Society of Hispanic Professional Engineers' competition on space travel).

A subset of participating seventh grade girls were told they had to maintain a B average to be a member in good standing, eligible for a mentor and career-related experiences such as job shadowing. Their grades showed an average increase (on a 4.0 scale) from 3.43 to 3.73 in science and from 3.32 to 3.4 in math. The first year's cohort (now in high school) had an overall grade point average of 3.43 during their first year in high school. The year before entering the project, their average national percentile rank score was 63. *During their first project year, their average national percentile rank score increased from 63 (the year before the project) to 74.8—an increase of 11.8 points. The district average that year was 58; the average for all middle school girls was 47.5.*

All of the students had gained confidence and planned to go to college. "When I see other women doing jobs that are mostly dominated by men," said one student, "it gives me confidence that I can do it also."

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Partners: Society of Women Engineers; New Frontiers/Center for Educational Development, Arizona Science Center; American Association of University Women, Glendale Union High School District, Arizona State University (Dept. of Psychology), and local engineering businesses.	
Keywords: demonstration, career awareness, gender equity awareness, teacher training, parental involvement, role models, mentoring, underprivileged, minorities, self-confidence, engagement, engineering, conference, hands-on, workshops, field trips, industry partners	

003
Hom
Developing hands-on museum exhibits

DEVELOPING HANDS-ON MUSEUM EXHIBITS

IN THIS PROJECT FOR EIGHTH GRADE GIRLS, FIVE "ENGINEERING" TEAMS DEVELOPED MUSEUM EXHIBITS FOR THE DISCOVERY MUSEUM, TWO ADJACENT HOUSES IN ACTON, MASSACHUSETTS, FILLED WITH FOCUSED SPACES AND INTERACTIVE EXHIBITS FOR CHILDREN OF ALL AGES. EACH EXHIBIT ILLUSTRATES A PRINCIPLE OF SCIENCE OR ENGINEERING, ALLOWING VISITORS TO LEARN THROUGH ACTIVITY-BASED LEARNING—AND ALLOWING THE GIRLS DEVELOPING THE EXHIBITS TO LEARN EVEN MORE.

Each engineering team comprised a female Tufts undergraduate, five eighth grade girls from the same school, and at least two mentors (a teacher and a mother), plus a support group: a Tufts University faculty member, a Tufts staff member, and a museum staff member.

Participants in one exhibit, for example, might compete in "feats of strength" using one of the five simple machines to develop "mechanical advantage": the inclined plane, wedge, screw, lever, or wheel. Participants in another might use Legos to learn about gears and the trade-off between speed and power with a lifting crane, a car, or a water well. To understand a mechanical clock (perhaps the most significant invention in the history of our modern world), one exhibit might show a clock constructed entirely from parts scavenged from children's toys. Another exhibit might display the fundamental relationship between switching circuits and Boolean algebra ("if X or Y happens but not Z, then Q results").

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Partner: Acton Discovery Museum	
Keywords: demonstration, recruitment, achievement, mentoring, hands-on, museum, project-based, engineering, parental involvement	

CLOSENESS IN AGE

As the father of two young daughters, engineering professor Ioannis Miaoulis wondered why girls would ever want to become scientists when commercials, movies, and even *Sesame Street* and *The Muppets* typically portrayed scientists as weird white men (usually ugly) wearing thick glasses, carrying 16 pens in their shirt pockets, and determined to destroy the universe. Images of women in science were typically posters of Amelia Earhart and Marie Curie, and he believed a 25-year-old computer programmer would be a better role model for an adolescent than a 90-year-old Nobel laureate.

Miaoulis concluded that it's *important for girls to have a role model or mentor fairly close to them in age*. Mentors for elementary school students might be middle school students who enjoyed doing a project for a science fair, mentors for middle school students might be high school girls who excel in math and science, mentors for high school girls might be college undergraduate or graduate students, and mentors for undergraduates might be young professionals.

003
RCH
Camp REACH: engineering for middle school girls

CAMP REACH: ENGINEERING FOR MIDDLE SCHOOL GIRLS

FOR SIX YEARS, CAMP REACH (REINVENTING ENGINEERING AND CREATING NEW HORIZONS) HAS BEEN OFFERING MASSACHUSETTS GIRLS—GRADUATES OF SIXTH GRADE—AN ENGINEERING SUMMER CAMP THAT INCORPORATES MATH, SCIENCE, AND ENGINEERING CONCEPTS INTO HANDS-ON ACTIVITIES. THE PROJECT DIRECTORS BELIEVE THAT *REALIZING WOMEN'S FULL REPRESENTATION AMONG ENGINEERS LIES IN COMMUNICATING WHAT ENGINEERS DO, HOW THEY HELP SOCIETY, AND WHAT SKILLS THEY NEED TO DO SO. YOU NEED TO CAPTURE THEIR INTEREST AT THIS AGE IF THEY ARE TO TAKE THE MATH AND SCIENCE THEY WILL NEED TO BECOME ENGINEERS.*

The camp encourages girls to pursue engineering through projects and workshops that promote teamwork, boost self-esteem, and establish close ties among the campers and with the faculty (the camp is held on the campus of the Worcester Polytechnic Institute). Workshops at the two-week camp reflect the various fields of engineering. At the forensic workshop girls do a chemical analysis of a mock crime scene; for structural engineering concepts, they examine sand castles built on Cape Cod.

One day the campers cross WPI's campus in search of handicapped-accessible (or inaccessible) features of the built environment, using wheelchairs. They note barriers, from inaccessible curbs to narrow elevators and doors without pressure-sensitive control mechanisms. Armed with rulers, calculators, and protractors, they retrace their steps to measure existing ramps and door jambs for compliance with the Americans with Disabilities Act (ADA). They learn about abilities handicapped people have that they don't—such as being able to turn in a wheelchair. To simulate what it is like to navigate with limited vision, they smear goggles with rubber cement and try to read signs and written materials. They compare their findings with ADA standards.

The girls work as a team on a community service design project to solve a problem for a local "customer." They may modify a bedroom for a disabled child, for example, or design a recycling program for a business. One group designed a Web page for Big Brothers/Big Sisters, using a text-based style to allow for compatibility with screen readers for the blind. Another picked ground cover (such as pebbles or wood chips) to make a new toddler playground wheelchair-accessible. Girls learn at the camp how engineering and technology are used to find solutions to some of the world's most pressing problems—for example, designing earthquake-resistant buildings and safer roads.

On July 22, 2002, Denise Nicoletti, a professor of electrical engineering at WPI and the camp's founder and director, was killed in a car accident, the victim of a teenage driver who had fallen asleep at the wheel.

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www.wpi.edu/~reach	HRD 96-31386 (one-year grant)
Keywords: demonstration, engineering, summer camp, self-confidence, teamwork approach, real-life applications	

003

Goz

Engineering GOES to middle schools

ENGINEERING GOES TO MIDDLE SCHOOLS

ENGINEERING CAREER DAYS AT DREXEL UNIVERSITY ALLOWED GIRLS IN PHILADELPHIA TO PARTICIPATE IN HANDS-ON ENGINEERING EXPERIMENTS WHILE INFORMALLY INTERACTING WITH PRACTICING FEMALE ENGINEERS AND ENGINEERING FACULTY AND STUDENTS. WITH THE GOES PROJECT (GIRLS' OPPORTUNITIES IN ENGINEERING AND SCIENCE), WOMEN IN ENGINEERING HELPED THE COLLEGE OF ENGINEERING TAKE CAREER DAY TO MIDDLE AND JUNIOR HIGH SCHOOLS WITHIN AN HOUR'S RADIUS OF DREXEL.

These traveling workshops in engineering education tried to get sixth to ninth grade girls to view engineering as a viable career option and to take college-track math and science courses that would prepare them for it. Workshops opened with a five-minute warm-up exercise in which girls identified what happened when they woke up and came to school, after which leaders explained how an engineer was involved in every single step. Given a handout listing various engineering specialties and salaries ("startling statistics"), the girls were asked to guess what percentages represented women. The girls loved their name tags, which indicated they were engineers for the day, attending a professional conference.

Hands-on labs (in which teachers and parents were encouraged to participate) conveyed the fun and excitement of engineering, captured students' interest, and acquainted them with the engineering profession:

- Polymers and microencapsulation (chemical and biomedical engineering)
- Sound and image processing, digital video, and videoconferencing (electrical and computer engineering)
- Slime, foam, and metals (materials engineering)
- K'Nex (a construction toy) and the design process (civil engineering)
- Groundwater contamination (hydrology and environmental engineering)
- Drills (mechanical engineering).

Schools preferred all-day to partial-day sessions (with 40-minute labs the best length), many girls began to lose interest in any activity after the third lab, and the girls liked having something to take home with them.

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HRD 94-53683 (one-year grant)	
Partners: Women in Engineering, DU's College of Engineering	
Women in Engineering programs for underrepresented populations: www.gatewaycoalition.org/underrepresented_populations/wie/support_programs.cfm	
Keywords: demonstration, engineering, hands-on, career awareness, workshops, role models, parental involvement	

003

Hop

Hands-on engineering projects for middle school girls

HANDS-ON ENGINEERING PROJECTS FOR MIDDLE SCHOOL GIRLS

FOR MANY STUDENTS, MIDDLE SCHOOL IS A TURNING POINT IN MAKING CAREER CHOICES. GIRLS EXPERIENCE SOCIAL PRESSURE NOT TO PURSUE TECHNICAL CAREERS, AND MIDDLE SCHOOL STUDENTS—ESPECIALLY IN RURAL AND INNER-CITY AREAS—OFTEN DON'T KNOW WHAT CAREER OPTIONS ARE AVAILABLE. AT BINGHAMTON UNIVERSITY, THE WATSON SCHOOL OF ENGINEERING LAUNCHED A YOUNG WOMEN'S TECHNICAL INSTITUTE TO LET GIRLS IN GRADES 6–9 EXPERIENCE SCIENCE AND ENGINEERING THROUGH POSITIVE, HANDS-ON EXPERIENCES IN A TWO-WEEK SUMMER SCHOOL. THE INSTITUTE, WHICH STARTED AS A PILOT PROGRAM FOR FOUR SCHOOLS, EXPANDED UNDER THIS NSF GRANT. BECAUSE OF ITS LOCATION, THE PROJECT ESPECIALLY HELPED RURAL GIRLS.

Middle school teachers, Binghamton faculty, and industry professionals worked together with the students in classroom activities. Teachers and girls had a common experience and teachers who worked as staff got a feeling for how they might do projects in the classroom that could be related to everyday problems. Parents were invited to project presentations so they could see what their daughters would need to learn to become scientists or engineers. *Everyone learned that there is more to technical subjects than textbooks—that the real fun starts with projects.*

The summer school curriculum consisted entirely of hands-on activities and field trips to local industries. The girls built robots, model rockets, paper towers, electronic circuits, paper and balsa airplanes, and amateur radio and TV antennae. They learned how to use drills, saws, tape measures, soldering irons, and the Internet. After learning how to program a milling machine, they tested how well their instructions worked in making the machine carve their initials into a piece of plexiglas. They solved math puzzles, did chemistry experiments, and learned how household appliances work. They built scale models of the solar system, constructed a model moon base, and visited the Kopernik Space Education Center.

Visits with role models brought to life their discussions of various kinds of careers. They were mesmerized when former television meteorologist Erica Boyd discussed what her career was all about. They did a little karate.

They were especially interested in projects relevant to helping others. *They found recycling paper and building solar ovens much more interesting than just talking about preserving the environment.* They loved learning the importance of mechanical engineering to buildings withstanding collapse in an earthquake. They built model buildings for an earthquake test and tested them using a shake-table, accelerometers, and computers. *Engaging in these activities brought latent interests to the surface in many girls*. Time will tell how many engineers, astronauts, or meteorologists the experience produces, but these middle school girls came to appreciate engineering.

In outlining procedures for an activity such as antenna building, the principal investigators added a *rubric for grading projects*. A rubric is a *well-defined point system for grading projects*, giving a certain number of points for creativity, understanding, display, cooperation, and so on—whatever is important for that project. *It is important that the students know the point system beforehand.*

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Keywords: education program, hands-on, teacher training, role models, engineering, rural, real-life applications, parental involvement, field trips, industry partners	

003

Pie

Partners in engineering

PARTNERS IN ENGINEERING

THE PARTNERS IN ENGINEERING PROGRAM BROUGHT TOGETHER A TEAM OF CLARKSON UNIVERSITY'S WOMEN ENGINEERING STUDENTS AND 50 SEVENTH AND EIGHTH GRADE GIRLS FROM THE LOW-INCOME, LARGELY RURAL REGION AROUND CLARKSON IN UPSTATE NEW YORK—SOME OF THEM HOME SCHOOLED. UNDERGRADUATE MENTORS, TRAINED DURING THE FALL SEMESTER THROUGH A THREE-CREDIT COURSE ASSOCIATED WITH THE PROGRAM, LED MIDDLE SCHOOL STUDENTS TO SOLVE A REAL-WORLD PROBLEM RELEVANT TO THEIR SCHOOL COMMUNITY—TO START WITH, REDUCING SOLID WASTE IN THE SCHOOL CAFETERIA AND INCORPORATING WASTE MATERIAL INTO CEMENT COMPOSITE. *EMPHASIZING TECHNICAL DETAILS MAY BE ENOUGH FOR YOUNG MEN, BUT GETTING GIRLS INTERESTED IN ENGINEERING GENERALLY REQUIRES SHOWING THAT IT CAN IMPROVE PEOPLE'S LIVES.*

The girls were challenged first to understand critical issues associated with the problem and then to find and implement an acceptable solution. Instead of memorizing a description of the problem-solving process, as they might in a traditional classroom, they experienced it firsthand. They met after school once a week for mentoring, leadership, and problem-solving activities involving math, engineering, economics, communications, and social studies. They visited a solid-waste separation facility, a waste-recycling facility, a landfill operation, a manufacturing facility that uses recycled materials, and an industrial facility—to see how they deal with their own wastes. They investigated the types and amounts of trash generated at school and conducted computer-aided analysis (spreadsheets, graphics) of the data. They designed a bench made of recycled materials.

This holistic, project- and problem-based approach to learning was a female-friendly vehicle for teaching STEM concepts and improving critical thinking and problem-solving skills. The project's collaborative approach to engineering benefited both the middle school students and their college-age mentors. Visiting speakers were local women in the sciences, about whom most of the middle school girls knew nothing.

Findings from the first year indicate that mentors, who were paid a stipend, served 10 to 14 hours a week, which did not interfere significantly with their academic progress. They all maintained fairly constant GPAs. Each mentor, after formal training, was assigned to two or three eighth grade girls, and three to five mentors worked together during a class period. The girls solved problems in small groups, which gave some of the quieter girls a chance to emerge as leaders. The eighth grade girls stayed in touch with their mentors by e-mail and often socialized with them at Clarkson's hockey games. *Most parents saw the mentoring as the most valuable aspect of the project, with hands-on experience in science and problem solving secondary.*

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HRD 99-79279 (ONE-YEAR GRANT)	
PARTNERS: SOCIETY OF WOMEN ENGINEERS, A.A. KINGSTON MIDDLE SCHOOL, AMERICAN ASSOCIATION OF UNIVERSITY WOMEN	
KEYWORDS: DEMONSTRATION, AFTER-SCHOOL, MENTORING, PROBLEM-BASED, ENGINEERING, UNDERPRIVILEGED, RURAL, PROJECT-BASED, REAL-LIFE APPLICATIONS, FIELD TRIPS	

003

GRi

Girls RISE

GIRLS RISE

IN THIS 18-MONTH INTERVENTION, A GROUP OF *HIGHLY MOTIVATED SEVENTH GRADE GIRLS*—MOST OF WHOM LIKED MATH AND SCIENCE AND WERE CONSIDERING STEM CAREERS—*LEARNED ABOUT ENGINEERING, A FIELD THEY HAD RARELY CONSIDERED AND KNEW LITTLE ABOUT*. THROUGH RECOMMENDATIONS AND INTERVIEWS WITH THE GIRLS, THE PROJECT SELECTED 24 GIRLS, MORE FOR THEIR INTEREST IN MATH AND SCIENCE THAN FOR THEIR GRADE-POINT AVERAGE, WITH AN EMPHASIS ON GIRLS OF COLOR.

Building on work the Miami Museum of Science had already conducted with underrepresented youth, the Girls RISE (raising interest in science and engineering) *project emphasized things that had worked before: the acquisition of advanced computer skills, the use of college-level mentors as instructors, interaction with professionals in the workplace, project-based active learning, and paid internships.*

Saturday sessions. During the school year, 23 girls attended 20 Saturday sessions at the museum. In the museum technology center's computer lab, mentors introduced the girls to MicroCAD (drafting and emulation software) and to communications and presentation software such as Hyperstudio. The girls learned to use e-mail and the Internet for fun and research, to scan and manipulate images with Adobe PhotoDeluxe, to prepare presentations integrating text and graphics using PowerPoint, and to create Web pages with Netscape 3.0. Each girl designed a personal Web page with links to her favorite engineering websites and kept an electronic journal. In two career academies, the girls interacted with women working in electrical, industrial, and mechanical engineering.

The girls learned engineering principles and conducted hands-on activities at a nearby elementary school. In an informal, collaborative setting, the girls felt safe experimenting with engineering concepts and processes and applying them to real-life projects. They completed projects in basic circuitry and learned about structural engineering through a bridge-building competition, group competing against group. To complement class discussions of bridge design, they visited different Miami bridges, taking photos and notes about the bridge construction materials—learning later why steel is no longer the material of choice and why concrete has replaced it for efficiency.

Summer Academy. Forty girls attended the Summer Academy. Girls new to the program were interspersed with girls who had completed the program during the academic year. Engineering students were recruited as mentor staff from the Society for Women Engineers, Florida International University, and the University of Miami. After a one-week orientation, the mentors helped the girls learn about different kinds of engineering through four weeks of presentations, research, and hands-on activities designed to teach specific concepts.

In cooperative learning groups, they built a line tracker and a miniature electric vehicle—designed to drive a set load up an incline. Each team member had an engineering position with specific responsibilities for design, facilities, development, or test engineering. Such projects helped the girls learn basic principles of electricity, electrical circuits, Ohm's law, conservation of energy, friction, gears and carrying power (gear ratio and wheel size), motor-carrying power, and aerodynamic drag.

In field trips to labs at the University of Miami, they spoke with engineers and students in robotics, environmental engineering, computer animation, and biomedical engineering. They toured the extrusion plant at the Cordis Corporation (seeing how catheters are made), and also visited Epcot Center, the IMAX Theater, and the Metro–Dade County Sewage Treatment Plant.

In the end, the girls not only knew more about engineering and female engineers, but most were more interested in science and technology and planned to attend math or science magnet schools and to pursue careers in STEM. *Most of the girls interviewed had changed their plans because of the program, had more perspective on how things are made and work, and were more aware of the options available to them.* Because parents influence their daughters' academic choices and careers and cannot all attend the final Family Night, it is important to find ways to convey similar information to them. The project would have benefited from having more mentors during the academic year (not just the summer) and from more formal mentor training and orientation—about computer programs, hands-on projects, adolescent development, group processes, conflict resolution, and social problem solving.

SECME RISE EXPANDS THE RISE MODEL

SECME Inc. (formerly Southeasthern Consortia for Minority Engineers) is a national organization that helps school systems provide hands-on engineering experiences for middle and high school students and encourages them to enroll in math and science courses. SECME RISE significantly expanded the Girls RISE model by integrating RISE strategies into SECME activities in 47 Miami–Dade County middle schools. The participants were mostly African American and Hispanic middle school girls from Miami's inner city who showed an interest in math or science. The project exposed this receptive young audience to fields unknown to them, involving them in engineering- and technology-related activities they could enjoy.

Peer leadership summer academy. A four-week session of computer-assisted, team-based engineering experiences built girls' confidence and boosted their interest in math and science. Mentors reported that some of the girls selected to attend the summer academy (two from each school) were neither outstanding students nor leaders in their schools. Some girls were not even initially interested in pursuing careers in STEM but were chosen because their teachers saw they could do well in science if someone could motivate them to become interested in school. The girls were intelligent but had behaved poorly in school and had no interest in academic activities. *Their parents credited the personal attention and hands-on activities they experienced in the academy with changing their children's attitudes toward school and toward their future careers.*

Many of the girls said the team mentors had influenced their thinking. The fact that three of the mentors were African American or Latina and had attended school in the Miami–Dade public system encouraged them to believe that they too could succeed as engineering students. It was important to these middle school girls that the mentors were attractive young ladies who wore nice clothes and had boyfriends—it counteracted their belief that female engineers would look and be "weird."

Four in-service teacher workshops. Each year, up to 32 teachers (two from each middle school) attended workshops that introduced them to e-mail (most had not used it), the Internet, and the graphing calculator, and learned about gender-fair teaching and how girls get excluded from the path to college majors and careers in STEM. The Myra and David Sadker video, "Gender Equity in the Classroom," showed subtle inequities in a middle school science lab and equitable strategies for managing the same classroom situations. Mixed-gender teams of teachers worked on engineering design challenges, observing firsthand the differences between competitive and collaborative processes.

Technology workshops might start with a warm-up game of Internet Lingo Bingo, introducing teachers to Internet vocabulary, followed by staff modeling the use of graphing calculators in hands-on math lessons. In the concluding workshop, teachers worked in teams to meet the most difficult design challenge: Using two sheets of paper, they had to build a support structure that would hold 20 textbooks more than two inches above the ground (a metaphor for building support structures for girls in their classrooms). Finally, they watched "Women Who Walk Through Time," *a video portrait of three successful women scientists, to change their vision of what was possible for their students. In general, the teachers valued and wished for more time spent on hands-on activities, on the computer, and on graphing calculator. They also valued time spent sharing and discussing gender equity issues with their peers.*

Over three years, 48 teachers attended national summer institutes designed to provide SECME club teachers with strategies, suggestions, and sources of support. SECME activities are designed to be flexible, and teachers were encouraged to adapt them to their schools' needs. In some schools, SECME clubs met regularly after school and hosted a variety of activities. In other schools, SECME activities were carried out as part of the regular science curriculum or were not carried out at all.

Family E-Days. Two special engineering days were held at the Miami Museum of Science for girls and their parents. Activities included design challenges for students and parents and talks by women engineers, with an emphasis on pathways toward college and careers in engineering and special seminars on standardized testing, college applications, and financial aid—plus a chance to explore the museum's exhibits.

Lack of transportation for students and of compensation for teachers lowered attendance at E-days and the teacher's technology workshops. Schools have limited budgets, few teachers receive additional pay or even expense money for work performed on Saturdays, and poor communication systems at some schools prevented notices of events reaching students and teachers or reaching them on time. For those who had access to it, the website was useful for keeping calendar and contact info current.

A number of significant accomplishments can be directly linked to the SECME RISE project. *By building robots and bridges and designing Web pages and PowerPoint presentations, girls demonstrated mastery of the engineering and computer skills the program introduced. More important, by the end of the program, the majority of the girls said they wanted to pursue science or engineering careers, and the majority of the students rated themselves one of the smartest, very smart, or above average in science.* The girls also learned to work in cooperative groups, to get along and become friends with girls from different backgrounds, and to resolve problems and interpersonal conflicts. *Almost all teachers who participated in the in-service workshops agreed that the training made them more aware of gender equity issues and more knowledgeable about the use of technology and hands-on engineering activities in the classroom.*

CODES: M, I, U, PD	Miami Museum of Science, Inc.
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www.miamisci.org/rise	HRD 96-31886 (one-year grant) and HRD 98-13891 (three-year grant)
Partners: SECME Inc.; Miami–Dade County Public Schools Urban Systemic Initiative; Miami–Dade County middle schools; ASPIRA of Florida; Boys and Girls Clubs of Miami, the Coconut Grove Youth and Family Intervention Center.	
Keywords: demonstration, cooperative learning, self-confidence, computer skills, career awareness, role models, project-based, internships, museum, hands-on, engineering, field trips, parental involvement, urban, African-American, Hispanic, teacher training, gender equity awareness, graphing calculator	

003
El
Engineering lessons in animated cartoons

ENGINEERING LESSONS IN ANIMATED CARTOONS

OFTEN YOUNG WOMEN DON'T GO INTO ENGINEERING BECAUSE THEY THINK IT'S TECHNICAL, DIFFICULT, AND BORING—AND FEW TELEVISION SHOWS FEATURE ENGINEERING HEROES OR HEROINES. THIS PROJECT HOPES TO ATTRACT STUDENTS TO ENGINEERING THROUGH A MULTIMEDIA PRESENTATION FOR ALL AGES—SEVEN CARTOON MOVIES VIEWABLE ON THE INTERNET, FEATURING ANIMATION, HUMOR, MUSIC, CHARACTER DEVELOPMENT, SOAP OPERA–LIKE DIALOGUE, AND HUMANIZED CHARACTERS INTERACTING AND USING BASIC ENGINEERING PRINCIPLES AND COMMON SENSE TO GET THEMSELVES OUT OF DIFFICULT SITUATIONS.

Each short cartoon movie presents a challenge in human terms, then explains and illustrates problem-solving approaches or engineering principles to address the challenge, and wraps up by reinforcing the moral of the story. In one cartoon, Pumpy Power (a female student) and Pipy Length (a male student), working on their final project, talk to each other about fluid mechanics in a water tower. Having made a series of mistakes, they are guided by the spirit of Daniel Bernoulli (of Bernoulli's theorem) to solve the problem themselves—by choosing two "smart points" along their assembly that define the smart system and smart process along the flow line.

By demystifying the field with cartoons that humanize engineering principles, the project hopes to interest students in the simplicity and intellectual beauty of basic engineering. All seven animated cartoons can be viewed on the Internet in roughly 90 minutes (allow for slow loading). At a Saturday workshop, 30 pre-college math, physics, and chemistry teachers viewed the cartoons and learned about basic multimedia programming and production.

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HRD 99-08753 (one-year grant)	
Partner: Rockford Public School District	
Keywords: demonstration, engineering, cartoons, problem-solving skills, teacher training, website, animations	

003
Pre
Pre-college engineering workshops

PRE-COLLEGE ENGINEERING WORKSHOPS

THAT MALE STUDENTS TEND TO IGNORE THE FEW WOMEN IN ENGINEERING CLASSES AND GRAVITATE TO OTHER MEN WHEN FORMING STUDY GROUPS OR WORKING ON GROUP PROJECTS CAN AFFECT THE WAY UNDERGRADUATE WOMEN PERCEIVE THEIR ROLE IN ENGINEERING AND THEIR SENSE OF BELONGING. WITH *JEMS* (JUNIOR ENGINEERING, MATH, AND SCIENCE), THE UNIVERSITY OF IDAHO OFFERED A TWO-WEEK SUMMER PRE-ENGINEERING EXPERIENCE FOR HIGH SCHOOL JUNIORS AND SENIORS—MALE AND FEMALE. NEW STRATEGIES AND APPROACHES WERE INCORPORATED INTO AN ONGOING SUMMER ACTIVITY THAT HAD NOT PREVIOUSLY SUCCEEDED IN ATTRACTING YOUNG WOMEN. WOMEN ARE OFTEN LESS INHIBITED IN ALL- OR MAINLY FEMALE CLASSES/SUMMER WORKSHOPS, BUT SUCH APPROACHES DON'T PREPARE THEM FOR THE PROBLEMS THEY WILL FACE WHEN THEY ENTER A COLLEGE OF ENGINEERING.

This two-week program was the first exposure to a university atmosphere for most participants, providing a useful transitional experience for mostly rural high school students. They registered for and attended a two-credit pre-engineering course, worked in university labs, and used other university facilities. The idea was to show engineering as a welcoming environment and encourage engineering as a career option.

A leadership unit informed participants about diversity issues (involving race, gender, and disability) and *encouraged male students' more acceptable (less adversarial) behavior toward female students—in the framework of "human factors engineering*." Faculty and counselors were given sensitivity and gender-equity training and as much as possible the project recruited female faculty and counselors (engineering undergraduates) to provide female role models. *Scholarships for female and minority participants were an important factor in recruitment*. Female enrollment increased from 10 in 1994 to 28 in 1995 (out of 57 total) and to 16 in 1996 (out of 36).

Instructors were trained to work with teams of students, to observe group dynamics, and to encourage team members to rotate all tasks, so girls weren't stuck with note-taking while the boys assumed leadership and did all the hands-on experimentation.

A scavenger hunt was the warm-up activity the first year, but in response to student feedback this was changed to an experiment in an engineering lab. To make the content more interesting, the emphasis shifted from mechanical engineering to environmental engineering. Student teams of two or four were responsible for a group project (for example, figuring out whether the wood-fired boiler on the Moscow, Idaho, campus provided the most cost-effective and environmentally safe option). They used CAD tools to design their project and to prepare posters and visual aids for its presentation to their families and other visitors the final day.

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Keywords: demonstration, engineering, summer program, research experience, career awareness, gender equity awareness, collaborative learning, hands-on	

003

Wi

WISE investments

WISE INVESTMENTS

SOCIALIZED TO ADOPT NURTURING AND PEOPLE-ORIENTED CAREERS, COLLEGE WOMEN OFTEN CONSIDER CAREERS LIKE ENGINEERING MORE DIFFICULT AND LESS IMPORTANT THAN CAREERS LIKE NURSING, ACCORDING TO ONE STUDY—THE PERCEPTION BEING THAT ENGINEERING IS NOT PEOPLE ORIENTED. ACCORDING TO ANOTHER STUDY, YOUNG WOMEN PLANNING CAREERS IN SCIENCE ARE OFTEN DRAWN TO THEM BECAUSE OF A DESIRE TO HELP PEOPLE, ANIMALS, AND THE ENVIRONMENT. THE IDEA BEHIND THIS ARIZONA STATE UNIVERSITY PROJECT WAS TO CONVEY THAT ENGINEERING IS A WAY TO HELP THE WORLD AROUND THEM, SO GIRLS AND STUDENTS IN OTHER UNDERREPRESENTED GROUPS WOULD STUDY MATH AND SCIENCE WITH AN EYE TO POSSIBLE CAREERS IN ENGINEERING AND THE APPLIED SCIENCES.

Many young women do not pursue science and engineering because they are not encouraged to. WISE Investments targeted middle and junior high and community *college teachers and counselors, encouraging them to convey the message that engineering is a helping profession*, that math and science have real-world applications (such as cardiac pacemakers and artificial kidneys), and that engineering welcomes women. It *targeted teachers and counselors at community colleges because half of ASU's undergraduate engineering transfer students do not decide to enter engineering until they are at a community college.*

Interactive workshops for teachers. Teachers and community college faculty participated in a two-week workshop featuring inquiry-based, hands-on labs conducted by ASU engineering faculty and graduate students. They also had the option of a one-week engineering internship in industry. The point of the workshop and internship was to familiarize them with the different engineering disciplines, get them excited about engineering, and help them develop applications they could use to get young women and minority students interested in engineering—and to answer a universal question, "When am I ever going to use math or science?"

They learned about gender-equitable teaching and experienced engineering labs that modeled gender-inclusive engineering activities and a collaborative learning style. They learned about eight fields of engineering (biomedical, chemical, civil/environmental, computer science and engineering, electrical, industrial, materials, and mechanical/aerospace). What they learned about engineering in the labs was reinforced by what they learned through industry tours and keynote speakers (women engineers or other company representatives). They organized and presented a Saturday academy for students. The project also provided year-long mentoring, two half-day follow-up sessions, and participation in an electronic forum.

Workshops for counselors. Counselors influence girls' career choices but are often left out of programs to encourage women to consider STEM career choices. After testing one-day and four-day workshops, the project offered a one-week workshop for counselors, overlapping with the one for educators. The counselors' session offered hands-on labs for engineering disciplines and sessions on recruitment and admissions requirements, financial aid, and career counseling in engineering for female students. They learn what it is like to be a female engineering student, what young women face, and how they have succeeded. Many of the participants had no idea what engineering was about and are now in a better position to advise their students.

Saturday academies for students. To counteract common perceptions of engineers as boring or antisocial nerds, the project invited 40 middle and high school girls and their parents to a dinner featuring a talk by a woman engineer. During the year, students participated in nine single-sex Saturday academies (each emphasizing a different area of engineering) and three industry tours. Pre-college students were also matched with female undergraduates majoring in engineering, who served as mentors and role models

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Partners: Northern Arizona University; Chandler-Gilbert, South Mountain, and Glendale Community Colleges; Phoenix, Tempe, and Chandler Unified High School Districts; Kyrene, Creighton, and Roosevelt School Districts; Intel Corporation, Motorola, Lockheed Martin, Anderson Consulting, Honeywell, Boeing Helicopters, Medtronic Microelectronics, and Salt River Project; the Phoenix Urban Systemic Initiative, the Arizona State Public Information Network (ASPIN), and other programs.	
Keywords: demonstration, engineering, community college, teacher training, real-life applications, inquiry-based, hands-on, gender equity awareness, internships, industry partners, career awareness, parental involvement, mentoring, role models, field trips	

003

k-12

Recruiting engineers in Kentucky, K–12

RECRUITING ENGINEERS IN KENTUCKY, K–12

SOUTH CENTRAL KENTUCKY NEEDED TO DOUBLE ENROLLMENT IN ENGINEERING TO MEET INDUSTRY'S NEEDS, SO IN 2001 THREE UNIVERSITIES—WESTERN KENTUCKY UNIVERSITY (WKU), THE UNIVERSITY OF KENTUCKY, AND THE UNIVERSITY OF LOUISVILLE—BEGAN OFFERING JOINT DEGREES IN CIVIL, ELECTRICAL, AND MECHANICAL ENGINEERING. BECAUSE *MOST K–12 STUDENTS HAVE NO IDEA WHAT ENGINEERS DO,* WKU'S ENGINEERING FACULTY BEGAN MENTORING LOCAL K–12 STUDENTS AND ENGAGING THEM IN HANDS-ON ENGINEERING APPLICATIONS.

Children who succeed despite adverse conditions usually do so because they got support from an adult other than their parents. Building on existing programs, WKU's engineering faculty is bringing engineering activities to elementary, middle, and high schools—to help students understand and appreciate the field and to elicit their interest in various kinds of engineering.

At local schools, engineering faculty are already mentoring impressionable children in engineering activities. One of them is offering an introduction to electrical engineering. After school for nine weeks children in grades 4–6 spend an hour learning about different kinds of engineering, by examining small machines and building small battery-powered devices. WKU's Center for Gifted Studies is also offering five Super Saturday programs for gifted and talented students in grades K–6, giving able students a chance to broaden their interests and develop their creative and critical thinking abilities. Students have 35 classes to choose from. In electrical engineering they can build a small flashlight, fan, boat, and cat; in civil engineering, examine structures and build miniature bridges and canoes, and so on.

In middle school, many children form preferences about subjects they will study in high school and college, so it is important that engineering faculty address their special needs. WKU's Center for Gifted Studies offers a two-week Summer Camp for Academically Talented Middle School Students. Roughly 180 residential students and 50 nonresidential students spend six hours daily, in classes of 90 minutes each, on topics ranging from computer science and math to science and foreign languages. In electrical engineering classes, they study basic concepts, engage in experiments, and build a small robot.

High school students have often decided if they are studying science but may know nothing about engineering. In 2000 the department of engineering organized a high school robot competition through BEST (Boosting Engineering, Science, and Technology) Inc., a Texas organization with 18 hubs nationally. Given a set of rules and a kit of allowable materials, teams of high school students have six weeks to design, test, and build a remote-controlled robot for competition against the other teams. *Building the robot under a time constraint with restricted materials is similar to what engineers do regularly*. In the Kentucky hub's first year, eight Kentucky teams (75 students) participated, creating a lot of excitement among area high schools. *Allowing students to creatively solve an engineering problem and to interact with team coaches (engineers from industry and faculty) has had a great impact on engineering recruitment.* Each kit costs about $700, but the university and local industry, not the high schools, provide the funds.

An engineering career day for students and their teachers offers hands-on engineering experiences for young women, as well as "a day in the life of a WKU student." The project also sponsored a weeklong summer workshop and two follow-up sessions for elementary and middle school teachers and counselors. *Changing attitudes has to start not just with girls but with their teachers and counselors, who, when made aware of subtle gender-inequitable mannerisms and the need for sound career advice, can generate different career expectations in the girls in their charge*. Parents, teachers, and counselors learn about gender equity issues and are given information about engineering, university housing, financial aid, and scholarships. Teacher participants are expected to make presentations to their peers about women's careers in science and engineering.

The younger girls are when you turn them on to science, the better the chances they will pursue it. But you have to give them some attention and they need role models to look up to—and to show them a possible future. The project is establishing a mentoring network, connecting women in STEM with college students and faculty at Western Kentucky University and with middle and high school students and science teachers in Bowling Green/Warren County and the state of Kentucky.

CODES: E, M, H, U, PD	Western Kentucky University
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Partners: Department of Engineering; WISE; Women's Studies; Center for Gifted Studies; BEST	
Keywords: demonstration, hands-on, mentoring, engineering, gender equity awareness, teacher training, parental involvement, career awareness, role models	

003

Real

Realistic modeling activities in small technical teams

REALISTIC MODELING ACTIVITIES IN SMALL TECHNICAL TEAMS

A COLLABORATION BETWEEN THE ENGINEERING AND MATH EDUCATION FACULTY AT PURDUE UNIVERSITY, THIS PROJECT WILL IDENTIFY LIKELY BARRIERS FOR WOMEN IN COURSES ON MATH TOPICS FUNDAMENTAL TO ENGINEERING AND WILL DESIGN ENVIRONMENTS IN WHICH THE SKILLS AND ABILITIES WOMEN BRING TO ENGINEERING ARE VALUED AND REWARDED.

Realistic, small-group mathematical modeling activities will be incorporated into selected early engineering courses at Purdue—including those required of all incoming freshmen engineering students—to demonstrate how their use in college engineering courses may address gender differences in interest and persistence in engineering. These activities will involve more than 3,000 freshman engineering students (about 600 women), all freshman engineering faculty and graduate assistants, and several faculty who teach sophomore engineering. Because the innovation will be systemic, it might well become a permanent part of the Purdue engineering program.

Complementing course lectures, the modeling activities should improve women's experiences in engineering by adding spatial reasoning experiences and contextualizing tasks (making clear who the client is and what the client needs). Presenting tasks in realistic engineering contexts should help students make stronger connections between course content and on-the-job engineering problems.

During phase one, all students in freshmen engineering courses will be required to collaborate in small mixed-gender technical teams on realistic modeling activities. To emphasize team communication, modeling will be presented in a structured environment, via WebCT (<www.webct.com>), an Internet-based instructional tool. All team members will be required to post their initial ideas about a problem's solution individually on the team's WebCT discussion board. After the initial posting by all group members, they will all have access to each other's initial responses. Then the group will be required to form one solution, or product, to respond to the client's needs.

During phase two, additional realistic modeling activities will be incorporated into sophomore-level engineering courses, providing more sustained experiences for a subset of students. This focused effort in sophomore engineering could generate innovation beyond the project's duration, since engineering faculty in fields such as mechanical engineering have expressed interest in working with the activity design team and have agreed to pilot a few activities. The activities design team is already part of Purdue's School Mathematics and Science Center.

During implementation, research will be done to shed light on how these modeling activities are used to identify emerging student talent; how various constituencies—male and female students and instructors—react to the use of these activities; how students use math and generate mathematical models in these activities; and how students' gender is related to their vision of a future career in engineering. This research will provide insights into the potential effects of small technical teams and realistic modeling activities in engineering courses, into the dynamics of gender equity issues in Purdue's engineering program, and into factors outside of engineering that may influence whether students (especially women) remain interested in and persist in the field.

In short, this project will initiate systematic changes in course content, providing an opportunity to study gender-related issues at the student, instructor, and program level. The modeling activities developed for this project will be made available as part of the Digital Library of Case Studies on Purdue's School of Education Twenty-First Century Conceptual Tools Center, and linked to the Women in Engineering Program. As progress reports and research reports become available they will be published on the same website.

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HRD 01-20794 (three-year grant)	
Keywords: demonstration, engineering, math skills, gender differences, collaborative learning, mixed-gender, research study, curriculum	

003
aW
Assessing women in engineering programs

ASSESSING WOMEN IN ENGINEERING PROGRAMS

WOMEN IN ENGINEERING (WIE) PROGRAMS AROUND THE COUNTRY ARE A CRUCIAL PART OF OUR NATIONAL RESPONSE TO THE NEED FOR MORE WOMEN IN ENGINEERING. THIS PROJECT WILL DEVELOP STANDARDIZED, EXPORTABLE, COMPARABLE ASSESSMENT MODELS AND INSTRUMENTS, ALLOWING COLLEGES AND UNIVERSITIES TO ASSESS THEIR WIE PROGRAM'S ACTIVITIES AND PROVIDE THE DATA NEEDED FOR WELL-INFORMED EVALUATIONS. THE PROJECT INVESTIGATORS WILL WORK WITH WIE PROGRAMS AT THE UNIVERSITY OF MISSOURI AND PENN STATE UNIVERSITY AND WITH COOPERATING PROGRAMS AT RENSSELAER POLYTECHNIC INSTITUTE, GEORGIA TECH, AND THE UNIVERSITY OF TEXAS AT AUSTIN. THE FIVE PROGRAMS COLLECTIVELY REPRESENT A VARIETY OF PRIVATE AND PUBLIC INSTITUTIONS, YEARS OF EXPERIENCE FOR WIE DIRECTORS, AND STUDENT BODY CHARACTERISTICS.

The project will develop pilot assessment instruments, implement and revise them, conduct preliminary data analysis, and disseminate reliable, valid, easy-to-access instruments. The principles of formative evaluation will be applied to all instruments and products, and all institutions will use the same set of instruments—giving them access to powerful benchmarking data as well as that from their own institutions.

An earlier project, the Women's Experience in College Engineering Project, sought to characterize the factors that influence women students' experiences and decisions by studying college environments, events, and support programs that affect women's satisfaction and persistence in their engineering major. By contrast, this project's target audience is WIE directors and its focus is on WIE programs, not students.

Data from these instruments should make it easier for directors of the roughly 50 WIE programs nationwide to make decisions about how to revise the programs or redistribute limited resources, and to provide substantiated evidence for administrators, advisory boards, and potential funding agencies.

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HRD 01-20642 (three-year grant)	
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Keywords: evaluation, benchmarks, data collection, recruitment, retention, assessment tools, engineering	

003
ise
Teaching inclusive science and engineering

TEACHING INCLUSIVE SCIENCE AND ENGINEERING

THIS MODEL PROJECT TO IMPROVE THE ENVIRONMENT IN WHICH WOMEN LEARN SCIENCE AND ENGINEERING BUILDS ON RUTGERS UNIVERSITY'S CURRENT KNOWLEDGE AND PROGRAMS, ESPECIALLY ITS PRE-COLLEGE EDUCATIONAL STEM PROGRAMS, ITS STRONG WOMEN'S STUDIES PROGRAM, THE EXPERIENCE OF DOUGLASS COLLEGE (RUTGERS' UNDERGRADUATE COLLEGE FOR WOMEN), AND A RECENT TWO-DAY SYMPOSIUM AMONG FACULTY IN SCIENCE, ENGINEERING, HUMANITIES, AND WOMEN'S STUDIES DEPARTMENTS, "BUILDING BRIDGES: BEGINNING THE CONVERSATION ACROSS TWO CULTURES."

The project designed and sponsored informal *faculty development workshops* to heighten the faculty's interdisciplinary knowledge of science, engineering, and women's issues. Scholars from science/technology and women's studies/humanities jointly facilitated the workshops, a natural outgrowth of the symposium. These informal workshops will help in establishing a *formal interdisciplinary seminar* spanning 14 weeks, based on a series of readings that raise issues for faculty to consider. Douglass College and the Institute for Women's Leadership will jointly sponsor two public events to highlight women's participation in science and technology.

Working together, scholars in science, engineering, humanities, and women's studies will design three variations on an *engineering studies module*—for students taking engineering courses, for women's studies courses, and for Introduction to Scientific Research.

Module 1, for young women already enrolled in engineering, will cover the history of women in engineering, as well as engineering problems and solutions of particular interest to women (for example, auto air bags designed for the average male and unsafe for women shorter than five feet). It will emphasize teamwork, an interdisciplinary approach to problem-solving, a total-systems view of society (emphasizing responsible knowledge and problem-solving), and students' learning and working styles as they relate to preferences for different engineering disciplines or subspecialties.

Module 2 incorporates a gender focus into Introduction to Scientific Research a prerequisite for summer science research internships offered to women in Project SUPER. Working in teams, students learn how scientists communicate, do literature searches, read scientific papers, prepare abstracts, analyze data, present results, and analyze the social implications of their research problem or project. They also discuss, for example, Rosalind Franklin's role in the work of John Watson and Francis Crick, and read June Goodfield's *An Imagined World: A Story of Scientific Discovery* (about the life and work of a woman scientist).

Module 3 stresses the importance of engineering and technology in a special section of Women, Culture, and Society, a women's studies course for first-year Douglass College students. Students read classic writers in feminist science studies (e.g., Helen Longino, Anne Fausto-Sterling, and Evelyn Fox Keller) and analyze case studies to learn how technology may lead to social change. A woman's introducing icons on Mac computers, for example, changed computer use from arcane and specialized knowledge (traditionally gendered male in our culture, for complicated but traceable reasons) to a more accessible everyday knowledge (traditionally gendered female). Representing the "delete" function with a trash can icon rather than a special code that had to be memorized democratized access to computer skills.

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HRD 99-08931 (one-year grant)	
Partners: Douglass College, the Institute for Women's Leadership	
Keywords: education program, teacher training, seminar, engineering, problem-solving skills, gender equity awareness, research experience, internships, women's studies	

003

d-m

Gender and team decision-making

GENDER AND TEAM DECISION-MAKING

ENGINEERING AND SCIENCE INCREASINGLY USE TEAM DECISION-MAKING—FROM WHICH WOMEN HAVE HISTORICALLY BEEN EXCLUDED—TO MEET THE NEEDS OF A RAPIDLY DEVELOPING TECHNOLOGICAL SOCIETY. RESEARCH SUGGESTS THAT THERE ARE INDEED GENDER DIFFERENCES IN GOALS, LEVELS OF CONFIDENCE, RISK PROPENSITY, PREFERRED DECISION PROCESSES, PROBLEM-SOLVING MOTIVATION, AND VERBAL, QUANTITATIVE, AND VISUAL–SPATIAL ABILITY.

We don't know what implications those differences will have for organizations as women ascend the corporate ladder. So few women work in engineering that it has been difficult to assess how women's inclusion in decision-making affects engineering decisions. This project from the Colorado School of Mines (CSM), an engineering university, is investigating how the gender composition of design engineering teams affects the decision-making process, the quality of the solution developed, the roles of team members, and the quality of their experience.

Women often exit engineering shortly after starting their college careers, so freshman and sophomore years are critical to keeping them in the engineering pipeline. This project will examine interactions between male and female first- and second-year engineering students enrolled in CSM's Engineering Practices and Introductory Course Sequence (EPICS) program as they try to solve open-ended problems in teams of four. Each year roughly 140 women (20 percent) and 560 men enroll in EPICS' 14 sections.

An open-ended problem has no single correct solution. Instead, students on the design teams use their knowledge of math, science, engineering, and computer science to develop one of many appropriate solutions. They might be asked, for example, to design a piece of interactive playground equipment for use by children with disabilities and their typical peers.

Six graduate students are being trained to observe team interactions using the observational guidelines of Jovanovic and King (1998). During a three-minute interval, observers will indicate a score of "1" for every behavior they observe and "0" for those they don't observe, indicating whether a student engages in (for example) *directing* (instructing other group members on the procedure and execution of the activity), *manipulating* (handling the materials/equipment), or *explaining* (explaining a science concept to another student).

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HRD 99-79444 (one-year grant)	
Keywords: research study, teamwork approach, self-confidence, gender differences, engineering	

003
dvs
Developing visualization skills

DEVELOPING VISUALIZATION SKILLS

COLLEGE WOMEN DROP OUT OF ENGINEERING PARTLY BECAUSE OF THE CULTURE AND PARTLY BECAUSE OF PRACTICAL PROBLEMS SUCH AS THE ONE THIS OHIO STATE UNIVERSITY PROJECT ADDRESSED: *WOMEN ACCUSTOMED TO ACADEMIC SUCCESS TEND TO LEAVE ENGINEERING IF THEY PERFORM POORLY IN EARLY ENGINEERING COURSES.* THE FIRST ENGINEERING COURSE OSU ENGINEERING STUDENTS OFTEN ENCOUNTER IS ENGINEERING GRAPHICS—A COURSE IN WHICH FEMALE OSU STUDENTS SCORE AN AVERAGE 12 PERCENTAGE POINTS LOWER THAN THE MALE STUDENTS. A POOR GRADE IN THIS COURSE CAUSES SOME TALENTED WOMEN TO LEAVE ENGINEERING, CONVINCED THEY CANNOT SUCCEED AS ENGINEERS.

The problem seems to be that *most women have trouble visualizing a three-dimensional (3-D) object, given a two-dimensional (2-D) representation such as a set of orthographic views or even an exploded assembly drawing. Assuming that girls don't experience enough hands-on activities to develop visualization skills, this project offers a workshop that helps them do better in engineering graphics*.

In a weeklong workshop, 30 women learned about tools and vocabulary by getting an up-close look at shop tools (such as drills, lathes, and welding equipment), using small hand tools (for example, to tap a hole), and handling and learning the characteristics of various fastening devices (such as nuts and rivets). While improving their skills and knowledge, the women also learned some basics about engineering and engineering courses.

To learn how to relate 2-D representations to 3-D objects, participants were asked to look at orthographic views of an object (on paper or on a computer screen) while holding and rotating the object; to rotate the object to orient it the same way it is oriented in an isometric drawing; to draw orthographic and isometric drawings of a solid object (manually or using a CAD system); to produce an isometric drawing based on a set of orthographic views; to carve a solid object from clay using a set of orthographic views; and to assemble an object from a set of parts, following an exploded assembly drawing.

The activities in this workshop were designed for the critical period between high school and college but could be incorporated into either high school or college courses.

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HRD 93-53774 (one-year grant)	
Keywords: demonstration, workshops, retention, visualization skills, engineering, hands-on	

003
tom
Sissies, tomboys, and gender identity

SISSIES, TOMBOYS, AND GENDER IDENTITY

SOCIOLOGY GENERALLY DEFINES "GENDER IDENTITY" AS "SOCIALLY CONSTRUCTED NOTIONS OF MASCULINITY AND FEMININITY." IN THE SPRING OF 1995, THE POWER PROJECT (POSITIVE OPPORTUNITIES FOR WOMEN ENGINEERS' RETENTION) SURVEYED 614 FACULTY MEMBERS AND 1,314 STUDENTS AT THE NEW JERSEY INSTITUTE FOR TECHNOLOGY AND FOUR NEW JERSEY COMMUNITY COLLEGES ABOUT ISSUES OF GENDER IDENTITY. SURVEY RESULTS REVEALED THAT *WOMEN ENROLLED IN ENGINEERING FELT THEY HAD TO HIDE BOTH THEIR FEMALENESS AND THEIR FEMININITY TO SUCCEED IN ENGINEERING*. LOOKING AND ACTING MORE MASCULINE—TO BLEND IN WITH THE BOYS—HELPED WOMEN SURVIVE. STUDENTS WHO WERE PREGNANT AND COULD NO LONGER HIDE BEING A WOMAN FELT ESPECIALLY VULNERABLE AND WERE NOT TAKEN SERIOUSLY IN THE ENGINEERING CLASSROOM.

Women appear freer about crossing gender identity lines than men. In response to the entry "Based on the way I dress, my outer appearance looks 'very masculine, somewhat masculine, both masculine/feminine, somewhat feminine, neither masculine nor feminine,'" all male faculty and most male students saw themselves as looking masculine, some women said they look masculine, but no male faculty member said he looks feminine.

Men may feel more pressure to conform to gender stereotypes from an early age: 95 percent of male students and 70 percent of female students reported that they were "normal" as kids. Only 3 percent of males said they were labeled sissies and three fourths of those "sissies" said they look masculine today. *Men may feel more compelled to look masculine than women feel compelled to look feminine.*

In this sample of students, about 30 percent of all women, half of the "masculine females," and a quarter of the "feminine females" reported being called tomboys as a child. There were no masculine-appearing or androgynous "sissy" females; all "sissy" girls described themselves as now appearing feminine. *Tomboyishness exists across all disciplines, but the incidence of tomboys increases in the traditionally masculine fields of the "hard sciences" and declines in the traditionally female fields of the "soft sciences" and the liberal arts. A masculine identity favors females in engineering science.*

For purposes of analysis, respondents who said they were either "both masculine and feminine" or "neither masculine nor feminine" were classified as "androgynous." Of *androgynous men, 80 percent identified as "neither masculine nor feminine"; of androgynous women, 80 percent identified as "both masculine and feminine"—a major finding that held true for both faculty and students. People's gender or biological sex seems to affect even the type of androgyny they choose*. Roughly 10 percent of the New Jersey faculty said they look androgynous—of which two thirds are women. Of 52 self-labeled androgynous people in the faculty sample, 81 percent are American and 85 percent are white.

There was a correlation between gendered boys' toys and a major in science, math, and engineering. *Few future engineers liked only girls' toys, as children, even if they were girls. In all disciplines, the majority of girls liked both girls' and boys' toys*. Again, girls felt more freedom to cross gender identity lines. It appears more girls were allowed to play with boys' toys than boys were allowed to play with girls' toys. The great majority (78 percent) of "androgynous" females and a majority (61 percent) of "feminine" females liked both girls' and boys' toys, while 43 percent of "masculine" females liked both girls' and boys' toys (half liked boys' toys exclusively). Even among feminine females (46 percent of whom major in the social sciences, mostly in the humanities, in this sample), 54 percent liked both girls' and boys' toys—only 42 percent preferring girls' toys. *(Parents and toy manufacturers, take note: Provide more girls' toys that teach the same math/science/spatial skills as boys' toys do.)*

Androgyny among men varies by race: 83 percent of androgynous white and Asian males preferred boys' toys, compared with only 57 percent of blacks and Hispanics. No Asian male played exclusively with girls' toys, but more Asian males played with both boys' and girls' toys than any other racial group. In this study, *whites appear less rigid about girls' gender identity than people of color. No black woman in this study was ever called a sissy.*

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Keywords; research study, engineering, gender differences, survey, gender identity, feminism	

Ethnicity and gender identity were the two of the most interesting variables in the survey. The majority of Asian (59 percent) and Middle Eastern (57 percent) faculty agreed that "women students won't have any problems in my department as long as they blend in with men." EuroAmericans (75 percent), Jews (67 percent), Indo-Pakistanis (56 percent), and other people of color disagreed (96 percent).

003

er

WISE scholars do engineering research

WISE SCHOLARS DO ENGINEERING RESEARCH

ALTHOUGH THE PIPELINE THROUGH WHICH YOUNG WOMEN TRAVEL ON THEIR WAY TO GRADUATE PROGRAMS IN ENGINEERING AND APPLIED SCIENCE LEAKS ALL THE WAY, WOMEN TEND TO EXIT AT THREE JUNCTURES, ESPECIALLY: AT THE POINT OF (NOT) CHOOSING A CAREER IN ENGINEERING, IN THE TRANSITION FROM UNDERGRADUATE TO GRADUATE (ESPECIALLY PH.D.) PROGRAMS, AND WHEN THEY MUST DECIDE WHETHER TO PERSIST AS ENGINEERS IN ACADEME AND INDUSTRY (WHERE THE ENVIRONMENT MAY BE HOSTILE FOR TOKEN WOMEN). THROUGH PROFESSIONAL DEVELOPMENT AND COMMUNITY BUILDING, THE LUCILE B. KAUFMAN SCHOLARS PROGRAM AT ARIZONA STATE UNIVERSITY (ASU) IS ENCOURAGING UNDERGRADUATE WOMEN IN ENGINEERING TO PURSUE GRADUATE DEGREES IN ENGINEERING.

Louise Kaufman was the first woman to become a faculty member in ASU's college of engineering and applied science. The Scholars program—a joint initiative of the graduate college, the college of education, and the college of engineering and applied science (CEAS)—combines professional development and community building.

The summer between her junior and senior years, a Scholar participates in an eight-week research experience, working about 200 hours with local faculty and receiving a $1500 stipend. The faculty working with the Scholars must attend a seminar on gender diversity. Fifteen faculty members with ongoing research projects have agreed to participate.

Scholars completing academic-year program activities also receive a $500 scholarship.

Every other week, workshops and seminars are presented on topics such as what you can do with a graduate degree in engineering, what to expect from graduate school, choosing a graduate program, breaking the glass ceiling, writing an effective résumé/curriculum vitae, how to apply for graduate school, interviewing to get in, gender differences in the classroom, and creative financing in higher education. Participants are invited to monthly networking events sponsored by the Scholars program and are notified of other relevant events. They are mentored and get to know one another and CEAS faculty. Mentors are recruited from ASU, local industry, the Society of Women Engineers, and other professional associations.

Self-efficacy is one's belief that one can perform a certain task or behavior. One builds self-efficacy through accomplishments, vicarious learning (seeing others model the behavior), encouragement and support, and physiological arousal (such as reduced anxiety). Expectations of self-efficacy are viewed as mediators of behavior and behavioral change. Expectations of outcome (one's belief about the consequences that will result) also affect one's motivation to perform a task or behavior. The Scholars program is giving its scholars opportunities for performance, accomplishment, vicarious learning, encouragement, support, and reduced anxiety. And they will be paid for their effort.

Project evaluation will compare Scholars' achievements with those of a cadre of comparably motivated women who did not participate in the Scholars program.

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KEYWORDS: DEMONSTRATION, ENGINEERING, RESEARCH EXPERIENCE, GENDER DIFFERENCE, MENTORING, SELF-EFFICACY	

003

mom

Bring your mother to (engineering) school

BRING YOUR MOTHER TO (ENGINEERING) SCHOOL

TO ATTRACT MORE YOUNG WOMEN TO ENGINEERING, THE SCHOOL OF ENGINEERING AND TECHNOLOGY AT CALIFORNIA STATE UNIVERSITY'S LOS ANGELES CAMPUS (CSULA) WILL EXPAND ITS MOTHER–DAUGHTER ACADEMY—AN INTRODUCTION-TO-ENGINEERING WORKSHOP FOR HIGH SCHOOL STUDENTS AND THEIR MOTHERS. ITS AIM: TO ENCOURAGE GIRLS AND THEIR MOTHERS TO CONSIDER ENGINEERING A VIABLE OPTION FOR WOMEN, TO DISPEL THE MYTH THAT ENGINEERING IS PHYSICALLY DIFFICULT AND UNFEMININE, TO RAISE THE LEVEL OF SCIENTIFIC KNOWLEDGE, AND TO FOSTER A PUBLIC APPRECIATION OF ENGINEERING.

Neda Fabris, a professor of mechanical engineering at Cal State, developed CSULA's first Mother–Daughter Academy in 1995, piloting it on a shoestring. Funded by state lottery income, the workshops have been well received and nationally publicized. Fabris hopes a tradition of Bring Your Mother to School will grow to complement Bring Your Daughters to Work.

Fabris starts her presentation about engineering by holding up a $20 bill and saying she will give it to whoever can name one thing in the room untouched by engineers. Participants often start with themselves; she mentions the toothbrush, coffee cup, and comb they used that morning. They mention air and she discusses smog, which comes mainly from automobiles, which are designed by engineers (whose influence may not always be positive!). She thought she was in trouble when a girl showed a silver ring made by American Indians but then explained how silver must be dug by picks and hammered. She always keeps her money and they get a lecture on how important engineering is to everyday life.

All but one of the daughters who participated in 1996 decided to study engineering, although only a few were considering it before the workshop. At least one mother, intellectually stimulated by the workshop, returned to school to work toward an advanced degree. Ratings were high for all parts of the workshop, with students preferring the hands-on contests and mothers preferring the theory and demonstrations.

"Overselling any profession does not yield results," says Dr. Fabris. "We all know that engineering is a hard and serious profession. Neither students nor professional engineers spend their time making Popsicle bridges and touring companies." *Activities need to be meaningful, yet attainable enough that participants can benefit from the experience.*

Now CSULA will conduct (and evaluate the impact of) two different models of the Mother–Daughter Academy. *The year-round academy* will consist of six five-hour sessions, combining lectures, videos, demonstration experiments, and hands-on contests. Contests scheduled involve girls in building a tower to hold a soda can, using Popsicle Sticks and rubber bands (related to civil engineering); an egg drop test (materials and mechanical engineering); assembling solar cars from kits and racing them (electrical and power engineering); and engraving their initial in a piece of hard wax using Mastercam software (manufacturing engineering). Participants will be introduced both to engineering careers and female role models and will visit a local high-tech company. Winners of hands-on contests and awards for best attendance and most enthusiasm will be awarded scientific calculators.

The project targets high school juniors, who often lack the math required for engineering and rarely consider a career in engineering, for lack of female role models, parental encouragement, or an understanding of what engineers do. Participants will be selected from schools participating in the Mathematics, Engineering, and Science Achievement program. The MESA office will monitor and track the girls' success and career choices.

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Keywords: demonstration, role models, engineering, parental involvement, career awareness, hands-on, teamwork approach	

A MOTHER'S INFLUENCE

Asked what they wanted to study, most high school girls answer, "I don't know." Asked who most influenced their career choices, they usually answer, "My parents"—and for girls, especially, "My mother." Intentionally or unintentionally, mothers influence their teenage daughters' career paths, typically know very little about math and science, and tend to perpetuate stereotypes about math and science being men's work, best avoided by women.

As the daughter of an open-minded mother, Neda Fabris was unaware of research on the subject at the time she launched the Mother–Daughter Academy, but she had noticed that mothers play a significant role in their daughters' career choices. And as the mother of two small children, Fabris noticed that PTA mothers often showed considerable interest in her career as a mechanical engineer. Several middle-aged women told her, often with a touch of sadness or jealousy, that they wanted to major in science or engineering but were discouraged from doing so by their mothers, counselors, and teachers. They were surprised when she told them that her mother, a foreign language teacher, had strongly encouraged her to study engineering. Fabris's mother, from her experience in Sarajevo (Bosnia) in World War II, had concluded that engineering offered a solid chance for survival and prosperity anywhere in the world. Although Fabris was scared to death of engineering, the more she learned, the more she came to enjoy it and agree with her mother. She also became convinced that mothers should be more actively involved in their daughters' academic and career choices.

At the June 2001 meeting in Denver of the Society of Women Engineers, Fabris accepted the Distinguished Educator Award. After a standing ovation greeted her acceptance speech, she said, "It is a long way from Sarajevo to Denver."

PHYSICS

003

X-P

Experiment-based physics for girls

EXPERIMENT-BASED PHYSICS FOR GIRLS

PHYSICS FOR GIRLS SHOWED FIFTH AND SIXTH GRADE GIRLS THAT SCIENCE IS FUN, WHILE INTRODUCING THEM TO BASIC SCIENCE CONCEPTS AND SIMPLE SCIENTIFIC EQUIPMENT. NOW EXPANDED INTO THE SEVENTH GRADE, THE EXPERIMENT-BASED PROGRAM WAS A COLLABORATION BETWEEN A PHYSICS PROFESSOR AT THE UNIVERSITY OF MISSOURI AND THE SCIENCE COORDINATOR OF COLUMBIA'S PUBLIC SCHOOL SYSTEM. THE VOLUNTEER PARTICIPANTS—SOME HIGHLY MOTIVATED, SOME LESS SO—BECAME MORE SKILLED AT BUILDING, EXPERIMENTING, AND LOGICAL REASONING.

The programs were taught by science teachers who were trained at three-week summer institutes, using the same materials and equipment their students would use. The project has developed and tested modules in

- *Optics* (the reflection, refraction, dispersion, and polarization of light)
- *Sound* (resonance in strings and tubes and sound as a wave—interference and beats)
- *Matter and mechanics* (air, air pressure, and Bernoulli's theorem)
- *Fluids, density, and Archimedes' principle* (the mechanics of solid objects, stability and equilibrium with torques and forces, the principles of conservation in simple machines—energy, linear, and angular momenta)
- *Electricity and magnetism* (circuits, or the flow of electricity; magnetic fields; and building small motors, doorbells, and burglar alarms)
- *Energy and rockets* (energy and kinematics, trajectories, collisions, dynamics, and energy conversion)

An average 25 to 40 girls participated in extracurricular after-school programs at 18 schools, with parents providing transportation. Local interest was high, and materials and sources were inexpensive. As a bonus, a female astronaut came to visit.

For each physical concept, children learned in a logical sequence to

- Play a game to internalize the concept
- Use the internalized concept to build a gadget, game, art project, or toy (thereby developing building and mechanical skills)
- Develop the concept through experiments, using simple scientific equipment and commonly available materials
- Perform mathematical analysis (for students in higher grades)

Wildly enthusiastic about the program, all the girls stayed till the end. A six-item instrument sampled their confidence in physics using pre- and post-tests, and comparing them with male and female peers who did not attend the program. *All girls showed less confidence than boys on pre-tests for optics and electricity, but after attending the program the girls reported more confidence, equaling or exceeding that of their male peers on all items in optics and in five out of six items in electricity.*

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KEYWORDS: DEMONSTRATION, SCIENCE EXHIBITS, TEACHER TRAINING, EXPERIMENT-BASED, HANDS-ON, PHYSICS, AFTER-SCHOOL, SELF-CONFIDENCE, REAL-LIFE APPLICATIONS	

MAKING BOUNCING BALLS

Newton Academy, a summer science academy for girls who have completed grades 9, 10, or 11. To give high school girls a chance to engage their hands and minds and to show them science's practical applications, the project invited 33 high school girls to make bouncing balls in an 11-day summer science academy. The girls spend a week building a miniature "toy factory" to produce the kind of bouncy balls sold in machines in grocery stores. Working in teams, they had to design a process to mix the materials, roll the balls, transport them from one place to another, and package them. They had to automate two of the manufacturing processes using machines they built themselves and were allowed to patent their designs.

Before building their factories, the girls dismantled copying machines, typewriters, CD players, and Teletypes, using reverse technology to understand the instruments' design and layout. They salvaged many small parts and devices—especially paper feeders for conveyor belts, and gears, motors, and pulleys—for their factory. *Some girls had never "taken stuff apart"—an activity traditionally associated with boys—and loved doing so. Girls who had grown up on farms had often taken things apart and put them back together before, but it was "cool" to have someone there to explain to them how things worked*.

They could purchase other needed parts—including wire, string, batteries, and duct tape—from a "store" in another classroom, using fake Newton dollars distributed to each team, which they had to budget. Before drawing up plans for their facility, they toured the university's engineering manufacturing lab and the nearby Unilever manufacturing facility, where they saw the value of precision and efficiency and got new ideas for their factories, such as using conveyor belts and doing different steps at different stations. Unexpectedly, they also became aware of the importance of reducing waste as they produced the balls. At their final session, a Family (pizza) Night, the students demonstrated their factories to their families and friends and sold their polymer balls. Their families were given Newton dollars to use that evening, which was a big hit among the younger siblings.

The program *allowed teenage girls to identify with their peer group, to see that other girls were interested in science, and to focus more on learning and less on the fact that they were working in an area traditionally dominated by males*. Meanwhile, in addition to their project mentors and role models, they had such visitors as an "awesome" woman from the Jet Propulsion Laboratory, who showed slides of Mars, watched the film *Contact* with them, and told them what was fact and fiction. Their interest in science and astronomy soared.

In producing the balls the girls learned math, computer programming, and graphing skills (determining the optimal mix of glue and borax required to get the highest bounce out of their balls), engineering (system design and factory layout), physics (gears, pulleys, and electrical systems), chemistry (encountering polymers, acid-based chemistry, absorbance spectophometry, and waste generation), economics and cost–benefit analysis (budgeting Newton dollars to purchase factory materials), and law (evaluating designs for novelty and completeness, for patents).

003
Sg
Selling girls on physical sciences

SELLING GIRLS ON PHYSICAL SCIENCES

ONLY 20 TO 25 PERCENT OF HIGH SCHOOL STUDENTS TAKE PHYSICS BEFORE THEY GRADUATE, WITH PERCENTAGES SLIGHTLY HIGHER FOR BOYS THAN FOR GIRLS. *MANY STUDENTS TAKE TWO OR THREE SCIENCE COURSES—ENOUGH TO MEET THEIR REQUIREMENTS—BUT NOT PHYSICS, WHICH THEY DON'T THINK THEY WILL NEED, VIEW AS A COURSE ONLY FOR THE TOP KIDS, AND ARE OFTEN SIMPLY AFRAID OF. WHEN THEY GO TO COLLEGE, WHERE PHYSICS IS REQUIRED FOR MANY FIELDS (INCLUDING ENGINEERING AND MOST HEALTH-RELATED PROFESSIONS), THEY GET CLOBBERED*.

This comprehensive University of Missouri (MU) program to engage girls from grades 5 through 12 in learning physics is a collaboration between MU faculty, teachers and administrators in the Columbia, Mo., public schools, parents, and local industries. Training, curriculum, and extracurricular activities emphasize hands-on learning—such as building a factory to produce bouncing balls—to spark girls' interest in the physical sciences and show them its relevance to their lives. Pre- and post-tests were administered in all project components.

"If they don't see that science is going to be useful, they don't want to take it," says co-director Meera Chandrasekhar, the MU physics professor who received a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring for the project. "Many girls don't feel they can do science, so they shy away from science courses. They are interested in science but haven't done much with their hands. That's where I started out. I really got interested in physics in my first year in college. I had a really good teacher and all of a sudden it just made sense."

Exploring Physics, an after-school enrichment activity for girls, grades 5–7. Middle school girls were offered units in optics, electricity and magnetism, and matter and mechanics. For each unit, they met twice a week for four weeks. In the first seven sessions the girls engaged in hands-on projects, using everyday materials. The eighth session was held in the evening so the girls could share what they had learned with family members.

In the unit on electricity and magnetism, the projects taught the girls the underlying principles of batteries, including those made from vegetables and those that are a natural part of the human body; electric generators; magnets and electromagnets; charging and discharging capacitors in electric circuits; and the resistance of common materials such as pencil lead.

Tests to measure changes in interest and confidence showed that before taking the program, neither the girls in the program nor a control group were as confident as a control group of boys, *but after the program the girls who took the program were as confident as, or more confident than, the boys, on all items but one (out of 12)*.

Saturday Scientist for junior high. With help from local industry, 98 students from three junior high schools learned about what they needed to study to pursue science careers, toured local industrial facilities, saw science professionals in action, and did experiments on their own. At Columbia Water & Light, for example, they built small houses from materials such as cardboard, plexiglass, and sheetrock, and heated them with a light bulb—measuring heat loss to see which material was the best insulator. With an infrared camera, they could see the "hot spots" in their houses and determine where heat loss was the worst.

FEST (families exploring science and technology). Science is rarely one of the things parents and children do together. FEST, which offered hands-on science activities for sixth and seventh graders and their parents, grew out of an earlier program for younger children. In two-hour sessions, children and their parents worked together to build a working drawbridge, incorporated concepts of structure, stability, gears, motors, and electrical circuits. They saw working drawbridges in a video and in clips from *Annie, The Blues Brothers,* and *The Wizard of Oz*. They got lessons on structure, gears, and electricity, and practiced skills they would need to build their own bridges. They built trusses from balsa sticks and tested their designs for strength. They investigated the effect of gear size on force and speed. In the electricity lesson, they assembled simple series and parallel circuits connected to motors and LEDs and learned how to operate a double pole–double throw switch, to operate the drawbridge. They built the floor and sides at home and assembled their drawbridges at the final session.

Parents and children enjoyed the time they spent together on building projects and suggested expanding the program to six or eight sessions and building more projects. *Establishing a positive relationship around science encouraged parents to encourage their children's pursuit of science.*

Summer physics workshops for teachers. In 1998, two one-week summer physics workshops were held, an optics institute (for 18 middle-school teachers) and a sound institute (for 21). Paralleling content covered in the schools and the student programs, the workshops taught concepts through hands-on activities supplemented by lecture, discussion, and problem-solving. For the sake of evaluation, teachers recorded their thoughts and questions in a learning log.

No one came to the workshop with a good understanding of optics, but all learned a lot and left with a much better grasp of a complex subject. They felt challenged and stretched but found the workshop an excellent and enjoyable way to learn difficult material. Initially, however, they were very anxious and not so optimistic. When they were clearly uncomfortable with the material being presented or what they were expected to learn, they interacted little, except to agree that they were confused. One heard, "I don't understand"—especially about frequency and the Doppler effect in the sound course and about focal length and the differences between concave and convex mirrors and lenses, in optics. After a few classes they settled down and began asking pointed questions and using the course terminology.

For their hands-on projects, participants applied their newfound knowledge by building an apparatus. Their projects—for example, a laser light show, a water xylophone, and a kaleidoscope—were all of high quality, some with innovative construction, and showed they'd assimilated the material. *Projects made the concepts concrete for them, reinforcing their understanding. Some participants said they felt they would retain what they learned because of the course expectations, the materials used, the enjoyable hands-on reinforcement of concepts, the real-world applications, and the many homework problems*. They became consultants, often answering questions for each other so the instructor didn't have to do so. In the flexible learning environment, the participants became interactive learners, showing a beginning mastery of the material. Some thought the hands-on projects took up too much (sometimes frustrating) time with no obvious benefit, but in listening to their presentations, looking at their uniformly good writeups, and knowing how far the participants' knowledge level had advanced, the evaluators concluded that the participants had learned a lot without realizing it.

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Keywords: education program, physics, hands-on, real-life applications, after-school, summer program, self-confidence, field trips, peer groups, mentoring, role models, career awareness, parental involvement, teacher training	

003

TNT

TNT girls go to physics camp

TNT GIRLS GO TO PHYSICS CAMP

IN 1998 THE COLLEGE OF ST. SCHOLASTICA PUT 35 MINNESOTA AND WISCONSIN SEVENTH GRADERS THROUGH A FIVE-DAY TOOLS AND TECHNOLOGY (TNT) PHYSICS CAMP, DESIGNED TO ENGAGE THEM AND THEIR PARENTS IN HANDS-ON PHYSICS ACTIVITIES. IT WAS THE SECOND IN A SERIES OF PROGRAMS TO SUPPORT A COHORT OF GIRLS AS THEY MOVED THROUGH K–12.

The girls started by building a pine toolbox. At first some girls were intimidated by the power drills, but soon they were vying for access to them. Guided by women scientists and instructors, they built large-scale inventions such as roller coasters, water-powered rockets, and motor-controlled planes. Each was given a hammer, pliers, and a six-in-one screwdriver to use at camp and to take home.

After building their own siege engine—a medieval invention to catapult objects—they launched the head of a Barbie doll, to mimic the medieval practice of launching diseased corpses over castle walls, to introduce disease among the besieged. Nestling Barbie's head in a sling, they tugged a rope, released a lever, and launched the doll's head in an arc across the college lawn. Her head was too light. By stuffing it with lead sinkers they made it heavy enough to launch. They also catapulted a motorized plastic pig, eggs, and fruit, learning through experience that potatoes and apples were a good weight for the purpose.

Working together, they learned about inquiry, teamwork, physics principles, and the use of tools. Betsy Fochs, a former pilot and a professor at the University of Minnesota at Duluth, taught them about conductors and transistors during a marathon appliance-smashing session in which they smashed open, tore apart, and studied the inner workings of telephones, VCRs, toaster ovens, TV sets, and parking meters. Exposure to science and women scientists is important at this age, says Fochs, "because *it's the age they start to think it's not cool to be smart.*"

As part of TNT, the girls experienced both the intensive summer residential camp and monthly follow-up activities during the school year. On Physics Fridays, they worked in pairs or teams on small-scale inventions that included a simple machine and demonstrated a principle of physics—culminating in a TNT Girls Expo at the Science Museum of Minnesota, whose staff participated in programming. The girls developed a website and presented their inventions with posters and PowerPoint presentations that illustrated their hypothesis, data collection, and conclusion.

They also took field trips to construction sites (to see large tools in action), the Science Museum of Minnesota, a robotics laboratory, an aerial lift bridge, a repair and maintenance facility for large aircraft, a pulp and paper plant, and, for the second cohort, a Science & Technology Weekend at The Works Museum in Eden Prairie, Minn.

The girls enjoyed working together on group construction projects, taking apart household objects, and making friends. Students and parents both noticed that the girls grew in *self-confidence, knowledge of physics, and social relationships. Students said they had better grades and were more familiar with technology.*

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KEYWORDS: DEMONSTRATION, HANDS-ON, PARENTAL INVOLVEMENT, SUMMER CAMP, MUSEUM, STAFF TRAINING, PUBLICATION, PHYSICS, WEBSITE, FIELD TRIPS, TOOLS, TEAMWORK APPROACH, INQUIRY-BASED, SELF-CONFIDENCE	

003

how

Changing how introductory physics is taught

CHANGING HOW INTRODUCTORY PHYSICS IS TAUGHT

TO REDUCE THE DROPOUT RATE FROM CALCULUS-BASED INTRODUCTORY PHYSICS COURSES, AND TO IMPROVE THE LEARNING AND RETENTION OF ALL STUDENTS (BUT ESPECIALLY WOMEN AND MINORITIES), A MODEL PROJECT AT THE UNIVERSITY OF MEMPHIS UNDERTOOK TO CHANGE THE WAY INTRODUCTORY PHYSICS COURSES ARE TAUGHT. THE PROJECT EMPHASIZED *CHANGES NOT IN THE CONTENT BUT IN HOW IT IS PRESENTED*, AN EMPHASIS THAT MAKES THE PROJECT PORTABLE FROM ONE COURSE OR DISCIPLINE TO ANOTHER AND PRESUMABLY MORE ACCEPTABLE TO MORE FACULTY.

Like much current reform in math and science, the project emphasized

- Increasing students' comfort level by establishing a sense of community in the classroom
- *Showing the subject's value and relevance in everyday life*
- *Making the course less competitive and more collaborative (encouraging small-group discussions and problem-solving, for example, and stressing collaboration rather than rivalry)*
- *Using problem-solving as a vehicle for understanding physical concepts and developing intuition*
- Adopting criterion-referenced grading (based on students' progress toward clearly defined class objectives) instead of grading on a curve
- Building students' confidence and skill at self-assessment
- Encouraging risk-taking

Teachers can encourage risk-taking and learning from mistakes by

- Emphasizing improvement and factor improvement into grades
- Emphasizing mastery of the material, not finishing fast, or first
- *Aiming at specific objectives (regardless of time or trials)*
- *Allowing students to drop their lowest grade or redo an assignment*
- *Giving some assignments that are ungraded but carefully read—with students getting feedback but not grades, thereby teaching them to separate the analysis of mistakes from their grade*

Naturally, reforming the way physics is taught and evaluated requires introducing new teaching techniques to STEM faculty—techniques for being more supportive of students and presenting the material in a way that helps engage them with the subject material and learn it better. It also means showing them how the old ways of teaching are turning off many students that the department and the scientific and technical workforce need.

Workshops for professional development emphasized developing awareness of the problem (how current practices limit opportunities for women and students of color), improving classroom climate and dynamics, developing alternative ways of structuring the course and testing for mastery, and improving the course content by providing concrete demonstrations and examples accessible and engaging to a wider audience.

Particular attention was paid to *helping students develop skills in self-assessment—knowing when a project is "good enough" to turn in and when it needs revision, when they have mastered a topic and can stop studying, when to ask for help, whom to ask*, *and what to ask*. Women tend toward underconfidence, so they often set lower goals and avoid risks—a problem exacerbated by many teachers' lower expectations, especially of women of color. Males are more likely to say "I did well," and females to say, "The teacher said I did well," laying emphasis on others' perception of their performance.

The project *taught students to avoid such dysfunctional ways of explaining success and failure, to understand their own role in that success or failure, and to correctly label any external influences on performance*. A teacher might ask students to predict how they will do on exams, for example, have them evaluate their own work, give them clear grading guidelines to help them do so, have them evaluate group projects and group participation, and ask for predictions before in-class physics demonstrations. Making predictions forces students to think about and evaluate factors that cause or affect outcomes. They should also be asked to reflect on discrepancies between their own evaluation and the instructor's.

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Keywords: demonstration, physics, calculus, retention, collaborative learning, real-life applications, self-confidence, teacher training, curriculum	

003

TIP

Teaching internships in physics for undergraduates

TEACHING INTERNSHIPS IN PHYSICS FOR UNDERGRADUATES

WOMEN REPRESENT 25 TO 45 PERCENT OF UNDERGRADUATES ENROLLED IN INTRODUCTORY PHYSICS BUT ONLY 10 PERCENT OF PHYSICS GRADUATE STUDENTS. MANY WOMEN COME TO THE UNIVERSITY OF ROCHESTER EXPRESSING AN INTEREST IN SCIENCE AND ENGINEERING BUT LEAVE SCIENCE IN THEIR LAST TWO YEARS. BY PROVIDING TEACHING INTERNSHIPS FOR UNDERGRADUATES, THIS MODEL PROJECT FROM ROCHESTER'S DEPARTMENT OF PHYSICS AND ASTRONOMY INCREASED BOTH THE NUMBER AND COMPETENCE OF INSTRUCTORS IN LAB SECTIONS FOR INTRODUCTORY PHYSICS. ONLY TIME WILL TELL IF IT INCREASES THE LONG-TERM RETENTION OF UNDERGRADUATE WOMEN IN SCIENCE, BUT THE PROJECT IMPROVED INSTRUCTION IN INTRODUCTORY PHYSICS ENOUGH THAT THE DEPARTMENT OF PHYSICS AND ASTRONOMY HAS INSTITUTIONALIZED IT.

At Rochester, all students preparing for science and engineering majors must take an introductory physics sequence and the associated lab course. Each semester roughly 600 students are placed in 20 lab sections led by graduate student teaching assistants (TA). This project recruited 20 undergraduate women concentrating in science as paid teaching interns (TIs), pairing each of them with an incoming graduate teaching assistant as co-instructors for the introductory physics labs. The undergraduate trainees were recruited from top-scoring sophomores and juniors (not just physics majors) who had already taken the course. The lead TA and the TI shared equally in teaching duties (except for grading, which the TAs did).

Before they got their assignments, the TIs were trained in teaching, leadership, and communication skills. *Instructor training was important for developing confidence, teamwork, and a sense that gender equity was valuable*. Both students and instructors benefited from the team and peer instruction. *The qualities brought to the classroom by the undergraduate TIs complemented those of the graduate student TAs: The TIs were closer to the lab students in age and level of understanding of physics, while the TAs knew more about physics.*

Initially concerned about being able to speak confidently before a group of students, some of the TIs feared knowing too little about physics to answer students' questions. Overwhelmingly, after the experience, they felt more confident about their ability to teach, to speak to a group, and to be a TI for a second year (even if it meant learning new lab material). As teachers, they learned how to be patient with undergraduates, how to get a point across, how to express the same idea patiently in many ways, and how to deal with different levels of understanding. They learned enough about the lab experiments to facilitate completion of the labs, and most of them learned enough about the subject matter, generally, to answer questions adeptly or to say "I don't know."

Undergraduates enrolled in the labs gave the TAs and TIs feedback about instruction through *small group instructional diagnosis*, a method for students to evaluate instructors midcourse through focus groups (or facilitated small-group discussions) to improve learning. *After the instructors discussed the feedback with them, students were more motivated*. Undergraduates had two sets of hands to help them in the lab courses and were largely happy with the interactive, one-on-one teaching they got on lab experiments, especially when TIs circulated, answering questions and giving them hints while the labs were in progress. They were impressed by the TIs' ability to explain the lab material clearly, felt most TIs knew the material well, and were more critical of timing than of clarity and coherence: *They suggested that instructors start the lab with a brief introduction and then dole out the rest of the details in installments as they reached that part of the lab work—rather than give them too much all at once*.

With one exception, TAs and TIs considered the relationship mutually beneficial. The TIs helped the TAs manage the lab and made their life much easier, and the TAs helped the TIs understand their physics homework. The TAs felt the TIs generally were well prepared, knew what they were doing, weren't afraid to ask questions and get clarification if they needed it, and knew the ins and outs of the labs even if they didn't always fully understand the concepts behind them. The TAs who spoke English as a second language were especially grateful for the TIs' help interpreting both the students' questions and the TAs' explanations. *The TIs bridged the TAs' understanding of what the undergraduates would not understand and got high marks from the students for being friendly, approachable, and accessible. The TIs learned about both physics and graduate school from the TAs, who as graduate students had a greater knowledge of physics.*

The dynamics changed the second year, when the project recruited 16 women and four men. A man volunteered to be lead TI, there was less continuity and cohesion in the group, and the project realized that, if the intent was partly to encourage female leaders, attention must be paid to male–female interactions as the program became institutionalized.

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KEYWORDS: DEMONSTRATION, PHYSICS, INTERNSHIPS, TEAMWORK APPROACH, SELF-CONFIDENCE, TEACHER TRAINING, GENDER EQUITY AWARENESS	

COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

003

Go!

GO team!

GO TEAM!

THIS PILOT AFTER-SCHOOL SCIENCE AND TECHNOLOGY PROJECT FOR UNDERSERVED GIRLS 11 THROUGH 13 IS AN OUTGROWTH OF THE SCIENCE IN THE CITY PROGRAM OF THE CHICAGO ACADEMY OF SCIENCES. DEMAND FOR THE COMPUTER TECHNOLOGY WORKSHOPS OFFERED THROUGH SCIENCE IN THE CITY WAS SO STRONG THAT WITHIN TWO WEEKS THE ACADEMY STAFF HAD TO ADD FOUR WORKSHOPS AND DEVELOP A NEW TECHNOLOGY WORKSHOP FOR OLDER GIRLS.

Responding to this incredible demand, the academy proposed to expand one of its most successful after-school programs, a program for (mostly affluent) students that combined learning about science with learning about computer technology. To broaden its reach into the Chicago community, for the new program—Girls Online (GO Team!)—the academy teamed with El Valor (two community centers serving a largely poor Hispanic population) and James Ward Elementary School, which serves a low-income mixed-ethnic population.

Each semester 45 girls will meet once a week after school in computer labs to learn basic Web design and to engage in hands-on learning in the natural sciences—ecology in the introductory class and water quality in the intermediate course. To offer a creative, engaged style of learning suited to girls, both classes will have the girls create a Web-based magazine, or “webzine,” for publication on the academy’s website.

In the first week of the introductory session, the girls will learn about a computer’s internal and external parts by taking apart a computer, but they will also learn about urban land habitats and ecosystems. The second week they will learn about information storage and computer operation as well as about urban water habitats and systems. As they learn about plant and animal defenses and camouflage, renewable and nonrewable resources, and energy resources, they will also learn about information transfer, the Internet, the World Wide Web, search techniques, digital scanning, and Web design. They will create a science-oriented Web page, using HTML.

In the intermediate class, they will use advanced HTML to create tables, frames, and animated GIFs, as they also learn about water chemistry, macro-invertebrates, and water quality. They will understand the factors involved in purchasing a computer and selecting an Internet service provider. Parents will be invited to events at the beginning and end of the 13-week session.

Two girls from each class will be teacher assistants for the next class. *They will also take part in a job shadow day with museum staff and other professional women in science and technology, because informal social sessions with adult scientists have been shown to change high school girls’ perceptions*. If girls team with a woman staff member as she goes about her daily routine and see that she is social and has a sense of humor instead of being “nerdy” and “strange,” they are more likely to select a science-related career.

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KEYWORDS: DEMONSTRATION, AFTER-SCHOOL, REAL-LIFE APPLICATIONS, UNDERPRIVILEGED, HANDS-ON, ROLE MODELS, COMPUTER TECHNOLOGY, HTML, MUSEUM, JOB SHADOW, WEBSITE, PARENTAL INVOLVEMENT	

003

Virt

Designing with virtual reality technology

DESIGNING WITH VIRTUAL REALITY TECHNOLOGY

THIS MODEL PROJECT FROM THE MIAMI MUSEUM OF SCIENCE AIMS TO INCREASE GIRLS’ CONFIDENCE, INTEREST, AND PREPAREDNESS FOR COMPUTER SCIENCE AND FOR HIGH-END CAREERS IN INFORMATION TECHNOLOGY. *BUILDING ON RESEARCH ABOUT GIRLS’ WAYS OF KNOWING, THE PROJECT IS DEVELOPING HANDS-ON CURRICULUM TO ENGAGE GIRLS IN DESIGNING—NOT SIMPLY USING—IT APPLICATIONS.* FOR 12 WEEKS DURING THE ACADEMIC YEAR, THE FIRST COHORT OF 44 MIDDLE SCHOOL GIRLS PARTICIPATED IN SATURDAY TECHNOLOGY WORKSHOPS, ACQUIRING THE SKILLS THEY WOULD NEED FOR INCREASINGLY SOPHISTICATED SOFTWARE APPLICATIONS.

Most of the girls were highly motivated, enjoyed working on computers, liked math and science, and were confident about their math and science skills. Nine of the girls had participated in an earlier academy at the museum. Most of the girls had access to computers at home, used them often, and were fairly familiar with e-mail and electronic chat rooms—but needed help learning how to use a CD-ROM drive, an external zip drive, a scanner, sophisticated database/spreadsheet software, and the multimedia software they would need for their summer project

Skill-oriented sessions engaged students in using the Internet, creating a public service announcement, creating personal Web pages, using a digital camera, taking and downloading digital images to their desktops, using Adobe PhotoDeluxe to manipulate and save images in formats suitable for incorporation into Web pages, working with graphics, creating panoramic views and object movies, and working with sound files. They would also learn math concepts needed to work with the virtual reality technology: perspective, measurement, scale, polyhedrons, and tessellations.

After finishing the 12-week series of Saturday workshops, the first cohort would complete a four-week intensive design studio, where (working in teams of four) they would produce an invention of their own design, using state-of-the-art virtual reality technology (VRQuest's 3-D Studio Max).

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Keywords: demonstration, museum, self-confidence, information technology, computer skills, math skills, virtual reality	

003

Why

Why girls go to whyville.net

WHY GIRLS GO TO WHYVILLE.NET

NUMEDEON, A SOFTWARE DEVELOPER FOR ONLINE COMMUNITIES, WAS SURPRISED TO DISCOVER THAT MORE THAN 60 PERCENT OF THE PEOPLE WHO USED ITS INTERACTIVE SCIENCE-ORIENTED WEBSITE (WWW.WHYVILLE.NET) WERE GIRLS, MOSTLY FROM GRADES 4–8. SINCE LITTLE COMMERCIALLY AVAILABLE SOFTWARE APPEALS TO GIRLS, NUMEDEON TURNED TO RESEARCHERS AT CALTECH'S PRE-COLLEGE SCIENCE INITIATIVE (CAPSI) TO LEARN WHY.

Whyville is a free and informal learning space launched in 1999 to help kids explore science concepts in a social and interactive learning environment. *Science activities embedded in the site* (presented in the context of a 3-D community) *promote inquiry, experimentation, and discussion*. On a typical summer day, more than 4,000 users visit the site, with a mean log-on time of 50 minutes. Users range from young children to college age, but most of its 225,000 registered users are 11 to 13. The popularity of Whyville with middle school girls is important, because this is the age when the gender gap in science often first appears. *Computer use in girls drops off dramatically after 13, for lack of games that don't involve speed, fighting, or competition.*

Whyville has become so crowded that it can't always accommodate all the users who want in. *Those who enter can chat with other users, visit popular gathering spots such as the town swimming pool, engage in noncompetitive games and activities, interact socially, or create their own identities.* Users especially love shopping at the "mall" for new face parts, clothing, or accessories for their online persona. They can create and sell items such as jewelry and face parts, or they can buy them from other Whyvilleans—with "clams," not dollars. Clams can be earned by engaging in science or math activities or by selling one's own products. The desire to buy things on the site motivates students to engage in and eventually master science activities. Whyvilleans who improve their performance increase their salary; they are further rewarded if they play the games many times over. They can also set up a charity to give away face parts to less fortunate citizens.

Although users may go to the site more to shop and to create new identities than to learn about science, the site is designed to draw them into science learning—in a constantly evolving scenario that affects their online lifestyle. For example, the site introduced a plague ("whypox") to trigger their interest in epimediology. Mysterious spots began appearing on the faces of a few of the most active Whyvilleans, spots that at first looked like freckles and later like red welts. The pox spread through contact. Several days of ugly faces and messages erased by virtual sneezes sent Whyvilleans scurrying for explanations to the bulletin board of Whyville's equivalent of the Centers for Disease Control, where they found a simulation of how disease spreads, a graph of how many Whyvilleans had been affected, and links to a real newspaper article about a wave of unexplained rashes affecting students in East Coast schools.

The site specializes in "edu-tainment," tapping the Internet's capacity for interactivity to get kids engaged in learning. CAPSI's goals are to analyze how much and what students are learning on the site and to explore what types of students (especially girls) are drawn to it. Besides surveying the Whyville population for background, demographics, and interests, CAPSI is doing pre- and post-assessments of science and technology interest for a group of students newly introduced to Whyville for the study. It is also monitoring the movements of the new users and a sample of current users to determine the activities of greatest apparent interest and appeal. Project researchers are conducting online and personal focus group discussions with current and new users to understand more fully their perceptions of the site. Project findings should provide suggestions for making educational websites more effective in attracting girls and may offer ideas for making school-based learning more appealing as well.

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Keywords: demonstration, website, inquiry-based, research study, informal education, engagement, interactive	

003

csR

Research in computer science

RESEARCH IN COMPUTER SCIENCE

RURAL LOUISIANA HAS ONE OF THE HIGHEST HIGH SCHOOL DROPOUT RATES IN THE NATION. FOR THAT REASON, RURAL STUDENTS WERE SPECIAL TARGETS OF A THREE-WEEK RESIDENTIAL COMPUTER SCIENCE PROGRAM TO EXPOSE MIDDLE SCHOOL GIRLS TO CAREER OPPORTUNITIES IN COMPUTER SCIENCE. HOSTED BY THE UNIVERSITY OF LOUISIANA AT MONROE, THE PROGRAM ACCEPTED 24 INCOMING EIGHTH AND NINTH GRADE GIRLS WITH GOOD GRADES AND AN INTEREST IN COMPUTER SCIENCE—GIVING SPECIAL CONSIDERATION TO PHYSICALLY CHALLENGED, MINORITY, AND RURAL STUDENTS.

Three weeks may seem like too long for middle school students to live on campus, but experience has shown that it is not, if the students are kept busy and happy. First the girls were introduced to computer science, computer problem-solving techniques, and popular software (including word processing, e-mail, a database manager, a spreadsheet, and presentation and programming tools). They learned HTML, developed their own Web pages, created and edited a newspaper, and developed presentations for a research symposium. *The more students use a technology, the less anxiety it produces*.

For two hours each afternoon they learned about expert systems, data mining, and software engineering, the broad topics within which they would conduct research in computer science. This part of the project *emphasized the science—seeking problems, forming hypotheses, performing tests, and finding solutions—in computer science*. On field trips to Black Bayou and Vicksburg, the girls saw concepts from computer science being applied in local industries and talked with scientists about their careers.

For three weeks, the participants lived in a campus residence hall, ate in university dining facilities, and participated in both program activities and unsupervised recreation such as swimming and volleyball. Six college students majoring in computer science served as the girls' "big sisters," living in the dormitory with them and helping them with program activities.

During the school year, they returned to the university on three Saturdays for follow-up activities, including preparation of a project to enter in a local science fair. To make follow-up visits feasible, the project limited recruitment to girls living within 50 miles of the university.

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Keywords: demonstration, rural, minorities, career awareness, role models, field trips, research experience, computer science, disabled, html, summer camp, computer skills	

003

Ole

Ole Miss computer camp

OLE MISS COMPUTER CAMP

THE UNIVERSITY OF MISSISSIPPI ("OLE MISS") LIES IN RURAL COUNTRYSIDE IN A RURAL STATE WHERE A HIGHER THAN AVERAGE PERCENTAGE OF CHILDREN LEAVE SCHOOL WITHOUT HIGH SCHOOL DIPLOMAS AND LIVE BELOW THE POVERTY LINE. THIS PROJECT BROUGHT RURAL EIGHTH GRADE GIRLS TO THE OLE MISS CAMPUS FOR AN INTENSIVE WEEKLONG COMPUTER CAMP (TO BUILD A SENSE OF COMMUNITY AND LAY A KNOWLEDGE BASE FOR LATER ACTIVITIES) FOLLOWED BY MONTHLY SATURDAY PROGRAMS AT LOCAL SCHOOLS, CULMINATING IN A CAPSTONE WEEKEND BACK ON CAMPUS

Girls often opt out of computer use because they are unwilling to compete with boys for computing resources. In girls-only sessions, the eighth grade girls in this project learned about basic electronics, computer platforms, operating systems, hardware, software, device drivers, user interfaces, and applications (such as spreadsheets, word processors, databases). They learned how to use e-mail and the Internet, built a home page and learned about algorithms. They played math and communication games. Dedicated sites for the monthly meetings allowed ample opportunity for hands-on experiences to bolster their computer skills, critical thinking, problem-solving abilities, and confidence.

Earlier research had shown that *mentoring—including online mentoring—by female role models is one of the most effective strategies for changing girls' self-images*. These girls networked with each other and benefited from face-to-face and electronic mentoring by undergraduate women in computer science at Ole Miss.

The teachers in charge of monthly site workshops (who were given a special two-day workshop before the girls' activities began) acquired contacts, new skills, and new insights into promoting gender equity in their schools.

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Keywords: education program, rural, underprivileged, computer science, hands-on, self-confidence, problem-solving skills, role models, mentoring, workshops, teacher training, gender equity awareness	

003

cool

Making computer science cool for girls

MAKING COMPUTER SCIENCE COOL FOR GIRLS

BOYS TYPICALLY COME INTO A COMPUTER SCIENCE CLASSROOM WITH A HIGHER COMFORT LEVEL THAN GIRLS, NURTURED PARTLY BY A WELL-DEVELOPED MARKET FOR BOYS' VIDEO GAMES. ON VIDEO GAMES, BOYS LEARN WHAT DOES AND DOESN'T WORK, TEST NEW IDEAS, AND "OUTSMART" THE MACHINE BY LEARNING ITS SECRETS AND STRATEGIES. SEEING BOYS UNAFRAID TO EXPLORE A COMPUTER AND EXPOUNDING ON TOPICS SHE DOESN'T UNDERSTAND CAN BE DAUNTING TO A NEW GIRL IN A COMPUTER CLASS.

At the heart of this University of Delaware *project to make computer science cool for girls* is POWER, an eight-week half-day summer camp for 20 juniors and seniors from high schools in Delaware and nearby Pennsylvania and Maryland. An all-girl activity for students good in math and at about the same skill level with computers, the camp *chose projects that involved programming for practical purposes the girls could relate to. It often had the girls work in groups, because some research shows that girls are less interested in the field since they believe computer specialists work alone with no social interaction—when in truth software development is typically done by project groups*.

Girls often describe their interest in computers in terms of "what they can do in the world" and how computers can link them to the worlds of education, medicine, communication, art, music, and so on. Designing Web projects allows them to see what interesting applications are possible with the programming skills they learn. *The Web's client-server model allows them to create socially oriented applications*, such as electronic RSVPs, shopping carts, chat rooms, and games. Animation, multimedia, interactivity, and graphic user interfaces allow them to be creative and artistic.

In camp the girls learned about static and interactive Web pages, electronic forms (rsvp, survey, etc.), Java applets, animated Web pages, GUI development with Java, and GUI-based interfaces. The project arranged for regular guest speakers from the business world and for occasional social activities. The three tenure-track women who served as faculty had often experienced being the lone woman in a class, especially in graduate school. Things are changing in the field and they hope projects like this will speed that change along.

Components for high school and undergraduate students will *reduce the sense of isolation women in computer science often feel by introducing role models, mentoring, and opportunities to work with other women in the field.*

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HRD 00-86424 (one-year grant)	
Keywords: demonstration, computer science, summer camp, role models, mentoring, field trips, research experience, teamwork approach	

003

C4T

Computer camp for teachers

COMPUTER CAMP FOR TEACHERS

SEVEN HIGH SCHOOL COMPUTING TEACHERS (THREE WOMEN AND FOUR MEN) FROM WISCONSIN AND SURROUNDING AREAS GATHERED AT THE UNIVERSITY OF WISCONSIN AT STEVENS POINT FOR A TWO-WEEK SUMMER WORKSHOP THAT PROVIDED TRAINING ON GENDER ISSUES, ELECTRONIC COMMUNICATION, AND INFORMATION SYSTEMS. THEY DEVELOPED GIRL-FRIENDLY LESSONS TO BE PILOTED WITH 19 HIGH SCHOOL GIRLS IN A SUBSEQUENT TWO-WEEK SUMMER COMPUTER CAMP. UNDERGRADUATE WOMEN SERVED AS TEACHING ASSISTANTS, ROLE MODELS, AND MENTORS TO THE HIGH SCHOOL STUDENTS.

All participants were connected electronically in a virtual learning community. Everyone learned about the university computer environment, e-mail, searching the Internet, and developing Web pages. (Another time, the project would probably also give experienced or fast-learning students a chance to learn C++, Visual BASIC, LegoLogo, and the like.)

That the summer camp for girls was free was important to some students, but making the camp free meant there were no consequences for canceling when a summer job turned up. The project recommended charging a nominal fee (such as $50) in later camps, which could be returned when the girl completed the camp. Recruiting qualified mentors/counselors was similarly challenging because university computer students typically have lucrative summer jobs or internships.

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HRD 97-11023 (one-year grant)	
Keywords: demonstration, gender equity awareness, teacher training, summer camp, computer science, collaborative learning, role models, mentoring	

003
tool
Retooling high school teachers of computer science

RETOOLING HIGH SCHOOL TEACHERS OF COMPUTER SCIENCE

CHANGING THE PROGRAMMING LANGUAGE USED IN THE EDUCATIONAL TESTING SERVICE'S ADVANCED PLACEMENT TEST IN COMPUTER SCIENCE FROM PASCAL TO C++ PRESENTED A WONDERFUL OPPORTUNITY: MOST OF THE ROUGHLY 1,500 TEACHERS OF ADVANCED PLACEMENT COMPUTER SCIENCE (APCS) COURSES NEEDED TRAINING IN HOW TO TEACH THE NEW LANGUAGE AND ITS OBJECT-ORIENTED STYLE OF PROGRAMMING. THIS PROJECT DEVELOPED A SUMMER PROGRAM THAT COMBINED THAT RETOOLING WITH TRAINING IN GENDER EQUITY ISSUES AND IN EDUCATIONAL PRACTICES TO RETAIN FEMALE STUDENTS IN COMPUTER SCIENCE.

Girls tend to be well represented in early computing courses but move on to advanced courses in far smaller numbers than boys. APCS courses are a perfect vehicle for increasing the number of women in computer science. By integrating gender equity activities with the training offered by a prominent computer science department with close ties to the Advanced Placement program, the project hoped to attract a substantial fraction of APCS teachers, who are key players in high school computing education nationwide. Integrating gender equity training into computer science training needed equally by both male and female teachers should make it more effective and equally attractive to all teachers.

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HRD 96-18865 (THREE-YEAR GRANT)	
KEYWORDS: PROFESSIONAL DEVELOPMENT, COMPUTER SCIENCE, COMPUTER PROGRAMMING, ADVANCED PLACEMENT, TEACHER TRAINING, GENDER EQUITY AWARENESS	

003
plug
Plugged in!: an interactive science website

PLUGGED IN!: AN INTERACTIVE SCIENCE WEBSITE

WHEN THIS PROJECT WAS PROPOSED, CLASSROOM COMPUTER EXPERIENCES TYPICALLY FAVORED THE DEVELOPMENT OF BOYS' SKILLS, AND COMMERCIAL SOFTWARE FAVORED COMPETITIVE "DEATH GAMES" (SUCH AS "MORTAL KOMBAT" AND "DOOM") THAT GENERALLY APPEALED MORE TO BOYS THAN TO GIRLS. "WHERE IN THE WORLD IS CARMEN SANDIEGO?," A GEOGRAPHY GAME FEATURING A SMART FEMALE CROOK, WAS THE CLOSEST THING TO A "KILLER AP"—A WILDLY POPULAR COMPUTER APPLICATION—FOR GIRLS. CARMEN APPEALED TO BOTH SEXES, THE SOFTWARE PROVIDED THE KINDS OF STORY-DRIVEN EXPERIENCES MOST GIRLS FAVOR, AND THE CHALLENGES WERE NOT JUST ABOUT WINNING.

The Mid-Continent Council of Girl Scouts and Ottawa University (aided by many other Kansas City, Mo., organizations) collaborated on creating an interactive, graphics-intensive science website for girls who get a kick out of being good at math and science. They concentrated at first on interactions between weather and the environment, making use of real-time data on weather, water, and soil. The idea was that girls could collect data from their own locations to supplement data published on the website, studying science by becoming scientists and contributing meaningful data. Girls' Science Network currently allows girls to share data on acid rain and light pollution.

Specialists designed interactive modules on such topics as water, birds, astronomy, fractals, and computers (demystifying their insides). A problem posed in the popular All-Weather Detectives goes like this: If a local tree farm was vandalized and several trees were cut down while the owner was away, how would a team of meteorologists evaluate the weather data and narrow down the time during which a footprint found at the scene could have been made? Would it be washed away in heavy rain? Was the soil frozen?

Panels of Girl Scouts tested each program. Ottawa University provided trainer training for classroom teachers and volunteer leaders in Girl Scouts and other youth groups. Many adults needed training on Internet skills, program activity options, and strategies for effectively teaching math and science skills to girls.

Plugged In! laptop programs were used at a resident summer camp for elementary school girls (along with Bridging-the-Gap Science Wonder tubs, from another NSF-funded project); at Tech Trek, a weeklong Scout science day camp for fourth through sixth grade girls held at Rockhurst College; and at a summer science institute at Ottawa University, where 44 Girl Scouts from grades 6 through 9 designed a research project. Plugged-In! classes held near Tonganoxie, Kans., offered girls in grades 1–12 hands-on activities involving weather, astronomy, exercise physiology, math, biology, and computers. Scout troops could access programs such as Fractal Finders and StarGazers on 20 laptops available through the council's computer checkout program.

CODES: E, M, H, I, PD	Mid-Continent Council of Girl Scouts
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www.plugged-in.org	HRD 95-55724 (three-year grant)
Partners: Ottawa University, Southwestern Bell, Kansas Collaborative Research Network, Rockhurst College, National Weather Service, Kansas City Museum, Society of Women Engineers	
Keywords: demonstration, website, interactive, Girl Scouts, trainer training, summer camp, hands-on	

003

box

What's in the box? diagnosing and repairing computer hardware

WHAT'S IN THE BOX? DIAGNOSING AND REPAIRING COMPUTER HARDWARE

INTERVENTIONS TO REVERSE THE SHARP DECLINE IN COLLEGE DEGREES IN COMPUTER SCIENCE OFTEN ASSUME THAT WOMEN'S INDIFFERENCE TO OR FEAR OF COMPUTERS IS RELATED TO ATTITUDES ABOUT SOFTWARE. BUT WOMEN MAJORING IN SCIENCE AND ENGINEERING AT PENNSYLVANIA STATE UNIVERSITY PERCEIVED THEMSELVES AS INEXPERIENCED OR INCOMPETENT WITH HARDWARE, NOT SOFTWARE. TO LEAPFROG A GROWING GENDER GAP IN COMPUTER COMFORT AND COMPETENCE, THE WOMEN IN SCIENCE AND ENGINEERING (WISE) INSTITUTE AT PENNSYLVANIA STATE UNIVERSITY DEVELOPED A PROGRAM TO OFFER HANDS-ON WORKSHOPS IN COMPUTER HARDWARE DIAGNOSIS, UPGRADING, AND REPAIR—GIVING YOUNG WOMEN A SKILL RARE EVEN AMONG THE COMPUTER LITERATE.

This project expanded on SCROUNGE (Student Computer Recycling to Offer Underrepresented Groups in Education), *a program that had successfully recycled industry-donated used computers to rural and inner-city schools. In recycling several hundred computers over four years, SCROUNGE had no woman apply to do computer repair, despite vigorous efforts to recruit women*. Even a female honors student in industrial engineering admitted being afraid to open up a computer for fear of breaking it—a common but generally unappreciated version of computer anxiety. Few women *or* men entering college engineering had experience doing computer repairs that require a screwdriver, much less such skills as soldering.

Dr. Richard Devon ran a pilot course in computer repair for undergraduate women majoring in science and engineering, providing collaborative, noncompetitive instruction, with many hands-on activities, including intentional computer glitches to test the students' developing competence. The WISE program added in-service teacher training to the undergraduate training because K–12 teachers who received the recycled computers reported not being skilled enough to troubleshoot the hardware and software problems that inevitably occur with computer use, or even to tell the difference between them. And nothing was more likely to ensure another round of disenchantment with computers in the classroom than schools failing to provide technical support.

Hence the WISE program, where young women were trained in diagnosing, repairing, upgrading, and maintaining personal computer hardware. At hands-on workshops, they were encouraged to take apart, test, and repair used computers solicited from local industry. *Publicizing that the "fixed" computers would be recycled to inner-city and rural schools attracted women to the program*.

Participants learned to diagnose common computer malfunctions, troubleshoot, and cannibalize parts to prepare used computers for reuse in schools and other nonprofit agencies. They learned techniques for repairing minor components (desoldering and soldering) and testing parts, using their computer toolkits. They learned to identify computer system boards and components and to demonstrate techniques for assembling, disassembling, installing, and configuring components—and for preventive maintenance. Workshop instructors covered the evolution of computers over time, suggesting ways for participants to assess their true needs against ever faster advances in the consumer market for computers.

This was not a remedial course. The goal of the training was to make women and girls more comfortable, competent, and independent with personal computers (especially computer hardware), less dependent on male gurus for handling common glitches in PCs, and better informed consumers able to choose compatible components and appropriate software. Some participants acquired the rudiments of a marketable skill in computer repair. Each participant took home a computer toolkit. The workshops were geared to women and girls but men and boys were accepted, partly to provide good role models for both boys and girls. The single-sex approach was not an issue.

The courses "sold out" quickly and most participants reported high levels of satisfaction with the instruction and greater comfort with and understanding of computers. *The training demystified computers, and participants reported feeling more relaxed and independent, with a better understanding of how computers work and more confidence, especially about troubleshooting*.

Teachers reported that participating in the workshops gave them more visibility within their schools. Several teachers reported promotions or other upgrades in status, particularly among the teachers who took year-long training at Wheeling Jesuit University. *By learning how to recycle computers at little or no cost, teachers learned how to exploit the rapid turnover in computers in industry to augment computer inventories in underserved inner-city and rural schools*. By becoming more competent and independent with computer hardware, teachers who took the workshops learned enough to help train other teachers, students, and staff members how to deal with computer glitches—an important area of competence in small and rural schools, which are far less likely than large or suburban schools to have computer or network specialists onsite.

The provost of Penn State University established the WISE Institute to recruit and retain women in sciences and engineering. *The idea was that exposing students early on, in a nonintimidating atmosphere, to computer hardware components would reduce attrition rates in computer science and engineering by reducing the gender gap in comfort and expertise with computers*. During 1998–2000, 386 women and girls and 108 men and boys—high school and undergraduate students, teachers, and members of the public—participated in hands-on workshops at five sites: Penn State University Park, Penn State Berks–Lehigh College, Penn State Altoona College, Temple University, and Wheeling Jesuit University.

Project findings suggest that *anxiety about computer hardware does contribute to women's current attrition rates in computer sciences and engineering. This modest intervention can be replicated by even the poorest school district and may help fill the void in technical support*. Such training can be adapted to other institutions and population groups, including undergraduates, teachers (through in-service or preservice training), Scouts, and vocational, technical, and high school students.

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www.psu.edu/dept/wise/wcache.htm	HRD 97-14759 (three-year grant)
Partners: Temple University, Wheeling Jesuit University, and Penn State University's Abington, Berks–Lehigh Valley, Altoona College	
Keywords: demonstration, hands-on, collaborative learning, intervention, industry partners, recruitment, retention, workshop, computer hardware, technical skills, self-confidence, computer science, teacher training, role models	

003
rp
Summer research projects in computer science

SUMMER RESEARCH PROJECTS IN COMPUTER SCIENCE

WOMEN IN THE COMPUTER SCIENCE DEPARTMENT AT THE COLLEGE OF STATEN ISLAND (CSI) DEVELOPED THIS ADOPT-AN-UNDERGRADUATE MENTORING PROGRAM, PAIRING UNDERGRADUATE WOMEN WITH SUCCESSFUL WOMEN IN INDUSTRY. THEIR PROJECT WAS MOTIVATED BY DATA SHOWING THAT *WOMEN'S PASS RATES IN REQUIRED AND MAJOR COURSES WERE SUBSTANTIALLY HIGHER THAN THOSE OF THEIR MALE CLASSMATES, BUT ALTHOUGH THE WOMEN WERE DOING WELL IN THEIR COURSEWORK, THE NUMBER OF WOMEN TAKING COMPUTER SCIENCE CLASSES ON CAMPUS WAS DISPROPORTIONATELY LOW AND, AS A PERCENTAGE, HAD BEEN DROPPING*.

The pilot project featured closed labs that met six hours a week, review sessions for introductory computer science, workshops for potential female majors about opportunities for women in computing, and the undergraduate mentoring program that encouraged students to complete their major and provided contacts for graduate school or job opportunities. The sample was small and the time frame short, but results were encouraging: The percentage of women majors in computer science increased from 16 (in 1992) to 21 (spring 1993) and then 28 (fall 1993).

With this NSF grant, the college-based program was expanded to Staten Island Technical School (SSTI). *For high school students, research recommended structured labs, group projects, and cooperative learning; formal peer, faculty, and alumni mentoring programs; and positive peer role models—pairing college students with high school students and graduate students with college students*.

Female graduates and alums of CSI gave lectures at the high school, and eight undergraduate women earned stipends for doing summer research with faculty mentors. During the summer of 1995, six students worked independently on mentored research projects, and three worked as a team. Their projects: a mobile robot laboratory, calculus for the blind, estimating robust parameters, multimedia courseware for teaching arithmetic to children, a graduate tracking program for SSTI, and a World Wide Web home page. The students presented their research at an expo at the college attended by SSTI students and their parents.

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Partner: Staten Island Technical School	
Keywords: demonstration, computer science, mentoring, role models, cooperative learning, peer groups, internships, research experience, career awareness, parental involvement	

003

WCS

Recruiting women into computer science

RECRUITING WOMEN INTO COMPUTER SCIENCE

THIS BOWLING GREEN UNIVERSITY PROJECT USED BOTH INSTRUCTIONAL AND MOTIVATIONAL STRATEGIES TO RECRUIT MORE WOMEN INTO COMPUTER SCIENCE. IT IDENTIFIED POTENTIAL CANDIDATES AMONG FRESHMEN AND SOPHOMORE WOMEN WHO WERE UNDECIDED ABOUT THEIR MAJORS AND INVITED THEM TO EXPLORE COMPUTING CAREERS AND A POSSIBLE COMPUTER SCIENCE MAJOR. IT IDENTIFIED THE FOLLOWING FACTORS AS *CONTRIBUTING TO SUCCESSFUL RECRUITMENT: AN EXPLORATION PROGRAM TAILORED TO THE SPECIFIC CANDIDATE (WITH COOPERATION FROM ADVISERS WHO WORK WITH UNDECIDED MAJORS), PERSONAL CONTACT WITH MEMBERS OF THE COMPUTER SCIENCE FACULTY AND WITH CORPORATE REPRESENTATIVES, VISITS TO BUSINESS WORKPLACES, AND COOPERATIVE EDUCATION ASSIGNMENTS.*

Many computer teachers are unaware of how their behavior and manner of interaction can undermine women students' self-confidence. As part of this project, computer science faculty, admissions personnel, and program advisers from seven Ohio institutions of higher learning and representatives from five corporations participated in two gender equity workshops. The workshops dealt with perceptual bias and stereotypes, language and gender, communication and learning styles, instructional alternatives, a computer science culture more inviting to women, faculty mentoring, and recruitment and retention strategies—including cooperative education.

Studies have shown that *cooperative education—placing students in a series of paid, supervised, and academically relevant work assignments in business and industry—enhances students' personal and professional growth*, making them more mature, self-confident, and independent. Students' interviewing skills improved because they took a co-op preparation course (which covered résumé-writing, interviewing, interpersonal skills, and career information—and interviews for co-op positions).

CODE : U	Bowling Green University
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HRD 94-53702 (one-year grant)	
Keywords: demonstration, computer science, recruitment, role models, field trips, self-confidence, gender equity awareness, teacher training, mentoring, retention, cooperative learning, career awareness, industry partners	

003
div
Improving diversity in the software development community

IMPROVING DIVERSITY IN THE SOFTWARE DEVELOPMENT COMMUNITY

THIS CARNEGIE MELLON UNIVERSITY PROJECT AIMS TO IMPROVE WEB-BASED EDUCATION PROGRAMS IN WAYS THAT IMPROVE DIVERSITY IN THE SOFTWARE DEVELOPMENT COMMUNITY. USING THE COURSES OF CMU SUBSIDIARY CARNEGIE TECHNOLOGY EDUCATION (CTE) AS TEST CASES, THE PROJECT WILL TACKLE RECRUITMENT, CURRICULUM, AND GENDER-EQUITABLE INSTRUCTION.

Recruitment. The project will develop materials to help onsite recruiters locate and enroll women and people of color in Web-based software development courses CTE already offers. The assumption is that the recruiters know their jobs and need only materials and techniques to reach groups currently underrepresented in software development.

Having studied websites and recruitment materials for postsecondary institutions around the country that serve women and people of color, the project is developing content for CTE's home page, course descriptions (in technical and plain English versions), pages about information technology (IT) careers and lifestyle, stories about people in various IT studies and jobs, and links to other helpful sites. There will be a text-only version of the website for vision-impaired users, and the project will draft a booklet for recruiters on effective approaches for recruiting women and people of color.

Curriculum. The project will develop and disseminate ways to make learning materials appeal to and serve the needs of diverse audiences. In exploratory efforts the project assessed some CTE content, tested male and female audiences' emotional and cognitive responses to sample content, then retested the sample content revised to incorporate explanations by analogy. *Project investigators found significant gender gaps in participation and performance and modified the content along the lines the literature suggested would narrow or close those gaps. A key challenge, they find, is determining what, exactly, constitutes a gap between members of different populations. Several gender gaps exist in CTE courses, and not all of them favor men*. Next steps are to analyze the causes for selected gaps and design and test changes in course content.

Gender- and race-equitable instruction. The project is developing a Web course on gender- and race-equitable instruction, intended for two different groups: local CTE instructors who will be meeting students in face-to-face classes and CTE employees who serve as mentors to the instructors. One module will use simulations.

CODE: U	CARNEGIE MELLON UNIVERSITY
ALLAN L. FISHER (ALF@CS.CMU.EDU)	HRD 00-80395 (THREE-YEAR PROJECT)
PARTNERS: WASHINGTON RESEARCH INSTITUTE, CARNEGIE TECHNOLOGY EDUCATION, CHROMOZONE, BRILLIANT DESIGN	
KEYWORDS: DEMONSTRATION, SOFTWARE, RECRUITMENT, GENDER EQUITY AWARENESS, CURRICULUM, WEBSITE, INFORMATION TECHNOLOGY, TEACHER TRAINING	

003
LINK
PipeLINK: young women in computer science

PIPELINK: YOUNG WOMEN IN COMPUTER SCIENCE

"WHAT'S THE GRATEFUL DEAD'S WEST COAST HOTLINE NUMBER?" TWENTY HIGH SCHOOL STUDENTS TRIED ANSWERING THIS AND OTHER QUESTIONS BY CRUISING THE INTERNET IN A COMPUTER LAB AT RENSSELAER POLYTECHNIC INSTITUTE. THE GIRLS WERE PARTICIPATING IN A PROJECT TO GET YOUNG WOMEN TO THINK ABOUT CAREERS IN COMPUTER SCIENCE. *WOMEN HOLD MANY JOBS IN MARKETING, GRAPHIC DESIGN, CORPORATE COMMUNICATIONS, AND PUBLIC RELATIONS, BUT THE HIGH-TECH FIELD DESPERATELY NEEDS MORE WOMEN WITH REAL TECHNICAL EXPERTISE*. GENDER EQUALITY IN THE INFORMATION AGE REQUIRES THAT GIRLS BE EXPOSED TO AND TAUGHT ABOUT COMPUTERS—EDUCATION THAT IS NOT HAPPENING NOW.

The pipeline to computer science shrinks as girls and young women move through school. Half of the high school students majoring in computer science are girls, but only 30 percent of BS or BA degrees in computer and information science go to women, only 28 percent of MS degrees, and only 16 percent of Ph.D.s. To attract girls and women to computer science and keep them there from high school through graduate school, this model project provided computer education for high school girls, research projects for undergraduates, and female role models in computer science for high school through graduate studies. Women further along the pipeline mentored those coming along behind them.

The high school students participated in a two-week computer science program at Rensselaer, where the girls learned about computers (especially enjoying e-mail, the Internet, and the Web), met women working in the field, and saw how many careers and topics there were to explore. Female graduate students and computer science professors visited the high school girls and talked about research and work in their field. Not surprisingly, some topics (such as computer vision, robotics, and sorting animations) were more popular than others.

Local high school students and math and computer science teachers were connected to women at Rensselaer through electronic discussions. PipeLINK provided the electronic network, paying for e-mail accounts for teachers and girls from 16 high schools, as well as for female undergraduates, graduate students, and faculty in Rensselaer's computer science department. Teachers at the high school learned about PipeLINK and electronic mentoring at one of three workshops during the project year. The electronic mentoring was used less than expected partly because of technical problems with the TeaMate system. Teachers thought it would be more effective if an undergraduate visited the high school at least once a week, so the girls had more face-to-face contact.

At Rensselaer, formal programs were held to aid students in transition from one educational level to the next—discussing what computer science majors do and how to adjust to college, options for computer science degrees, how to apply to graduate school, work in industry (with a BS or MS), adjusting to graduate school, doing research, and getting a faculty job. Distinguished computer scientists from academia and industry spoke and held informal discussions with young women studying computer science, encouraging them to take part in undergraduate research projects.

Nine undergraduate women participated in a 10-week summer research program, each working with a faculty or graduate student mentor and in turn serving as teaching assistants and counselors for the high school program. Each undergraduate made a research presentation to the high school students and other undergraduates. The mentors helped the undergraduates prepare their talks, suggesting visual aids when possible. The undergraduates were well prepared and captivated the high school students. At least one undergraduate plans to pursue a Ph.D. because of this experience. They all plan to apply to graduate school.

CODES: H, U, PD	Rensselaer Polytechnic Institute
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www.cs.rpi.edu/~walkere/pipelink	HRD 94-50007 (one-year grant)
Keywords: demonstration, computer science, role models, self-confidence, research experience, role models, mentoring, electronic mentoring	

003

bot

Agents for change: robotics for girls

AGENTS FOR CHANGE: ROBOTICS FOR GIRLS

WHEN THEY WERE FIRST INTRODUCED, COMPUTERS WERE OFTEN VIEWED AS FANCY TYPEWRITERS, SO COMPUTER EDUCATION LARGELY INVOLVED TEACHING KEYBOARDING AND FILE AND DISK MANAGEMENT. AS TECHNOLOGY SHIFTED TO APPLICATIONS, STUDENTS HAD TO LEARN TO USE WORD PROCESSING, SPREADSHEET, AND GRAPHICS SOFTWARE AND INTERNET BROWSERS. BUT *INTERFACE-LEVEL FAMILIARITY WITH APPLICATIONS MAY NOT GIVE STUDENTS ENOUGH BACKGROUND TO BE TECHNOLOGICALLY COMPETENT WITH SOPHISTICATED INFORMATION TECHNOLOGY*. CURRENTLY AVAILABLE HARDWARE AND SOFTWARE WILL SOON BE SUPERSEDED AS INFORMATION TECHNOLOGY SYSTEMS MOVE TOWARD INCREASINGLY INTELLIGENT OR "SMART" TECHNOLOGY, EMBODYING VARIOUS FORMS OF ARTIFICIAL INTELLIGENCE.

This University of Pennsylvania (Penn) project is developing school-based and informal education robotics curriculum and activities to engage middle school girls in advanced IT. The "virtual pet" craze showed that robotics can be approached in an appealing, age-appropriate manner. When Penn's General Robotics and Active Sensory Perception (GRASP) lab suggests to middle school girls that a virtual pet is simply an interactive graphic simulation and that they can create their own, they head for the nearest keyboard.

Visitors to the GRASP lab quickly see robotics as a creative, cooperative, horizon-expanding endeavor aimed at improving people's safety, independence, and quality of life—not the lone scientist toiling at a cluttered workbench. They see a "smart" wheelchair developed to climb curbs, robotics devices for quadriplegics, and small robots being designed to play "robot soccer." A central research theme in the lab is "cooperative robotics": designing robots that can work intelligently and adaptively as partners with each other and with people.

In this project's work with sixth to eighth graders, important concepts in robotics are introduced in lively, even humorous ways. A graduate student in computer science becomes Rosy the Robot, for example. Armed with a list of commands Rosy can carry out and objects she recognizes, students must write a program for her to paint a bookcase. When Rosy does exactly what she is told, with mildly disastrous (but entertaining and instructive) results, students quickly realize that what they take for granted in human perception, action, and communication must be analyzed and specified in great detail for a robot. This simulation is a tool for introducing the programming concepts of functions, loops, logic operators, and conditions.

The project is not about helping students "feel comfortable" with technology or giving them limited-purpose skills such as word processing or multimedia navigation. *As an interdisciplinary, problem-based blend of science, math, engineering, and technology, robotics—the design and study of intelligent, autonomous agents—fits beautifully with current standards-based recommendations for STEM education. Adding robotics to the middle school curriculum does not "push out" other STEM content*. It is a good vehicle for improving pre-college STEM education, providing an entry point for learning appropriate to the new century. It motivates students to study such basic topics as electrical circuits, mechanics, optics, geometry, probability, and statistics. And as students pursue robotics projects, they may well find themselves drawn toward computer science, math, engineering, psychology (perception, human factors), cognitive science, and physics.

Moreover, robotics projects—maybe because they produce new creations that actually do something—are unusually successful in getting students to take ownership of their learning both in and out of school, to set increasingly sophisticated goals for themselves, and to work in a focused, sustained way to achieve an outcome. Introducing robotics in middle school opens an intellectual domain that is not yet effectively represented in the pre-college curriculum. It puts students in productive control of smart technology rather than making them feel that are at its mercy or are locked out of environments that use it. This project will

- Develop a comprehensive series of after-school and summer education programs—some based in the robotics research lab—based on girls' interests and preferences and emphasizing their relationships with mentors and role models.
- Develop and implement a gender-fair, multidisciplinary robotics curriculum for middle schools as a series of project-based learning modules, providing substantial professional development for teachers on both content and gender equity. The curriculum will emphasize *information engineering*—the encoding, transfer, processing, and interpretation of information in interactive technology systems. Core activities will use the Lego Mindstorms Robotics Invention System™—the most readily available, cost-effective, reusable, and robust of the systems evaluated.
- Engage teachers and students in a change process leading to equitable STEM learning environments that support high achievement for underrepresented students.
- Disseminate age-appropriate instructional materials for project-based learning in robotics that can be implemented in both informal and school-based settings.
- Conduct new research on the relative impacts of formal and informal STEM learning programs on achievement and persistence in, and attitudes toward, science and technology—examining the effects of both program characteristics (e.g., single-sex versus mixed-sex, school-based versus informal) and student characteristics (gender, race/ethnicity, prior achievement in math and science, family income level, and urban versus rural).

HOW WELL THESE MIDDLE SCHOOL STUDENTS UNDERSTOOD IT

In a baseline study to probe how much middle school students understood IT systems, the project learned that there was *no difference in boys' and girls' access to and frequency of use of computers and the Internet*. They e-mailed friends, did Internet research, played games, and sought information about personal interests and hobbies. Offline, they played games and wrote reports for school. Most students could describe how to get on and use the Internet and some could describe various button and menu operations at the level of "do this and you'll get that." *Fewer students could describe what was happening outside the room they were working in. Some students made no distinction between the Internet and their browser or service provider—thought the Internet was America Online. Rural students fared somewhat better than urban students but there were no significant gender differences*.

When students were asked to reverse-engineer several mechanical and electronic artifacts, researchers noted when responses attributed (or denied) to an artifact some kind of information processing function (e.g., mentioning sensors that picked up information from the environment or some kind of hardware or program that controlled the artifact's behavior). *Rural students scored significantly higher on the more advanced subscales and a reliable gender difference emerged, with boys scoring higher than girls on two of the information processing subscales*.

Despite concern about the "digital divide," there was reason for optimism. *The gap between girls and boys and between urban and rural students was not as wide as they expected, despite the urban sample's bias toward the low end of the socioeconomic range. For this generation of students, digital technology is not the restricted domain of a few "nerdy" peers, but the sea in which they swim*. These 11- to 13-year-olds do not remember a time when there were no cell phones or e-mail or laptops or digital toys. Most students—male and female, rural and urban—were enthusiastic, confident, and frequent users and consumers of IT products and services. *Reliable differences in understanding that emerged—especially between rural and urban students (who also differ socioeconomically)—were generally contained within a broad middle range. All students knew something but few students were conceptually sophisticated.*

Under current standards for technology education, few if any of the students were achieving the level of skill and knowledge in IT indicated for their grade level. None were able to think productively and robustly about the entities and processes underlying IT. The processes involving encoding, transmitting, receiving, storing, retrieving, and decoding information in technology systems were largely a mystery to them. Many learned to do Internet research in school, but much of what they know was either self-taught or learned informally from peers and relatives. The formal education required to move students from being superficial users and consumers of technology to being problem-solvers and designers has not yet been established in public education.

Even with present-day technology, effective problem-solving, decision-making, and troubleshooting requires behind-the-scenes knowledge and strategies for applying that knowledge to new cases. (For example, to avoid filling a hard drive with large graphics files, girls can't decide to use more economical formats or software that compresses files if they don't understand that a picture exists not as a picture but as a data file.) And as intelligent technology becomes more embedded in "smart" artifacts that do not resemble a desktop computer, students will need a solid base from which to assess novel systems that do not resemble the systems with which they are familiar.

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HRD 99-76527 (three-year grant)	
Partners: Penn's GRASP lab; the Washington (CHAIN) and University City middle school clusters in the School District of Philadelphia	
Keywords: education program, robotics, information technology, engagement, after-school, project-based, research study, gender differences, informal education, teacher training	

003

Sat

Self-authorship and pivotal transitions toward IT

SELF-AUTHORSHIP AND PIVOTAL TRANSITIONS TOWARD INFORMATION TECHNOLOGY

WHAT ARE THE PIVOTAL TRANSITION POINTS IN GIRLS' LIVES THAT DETERMINE WHETHER THEY SEE INFORMATION TECHNOLOGY AS A VIABLE CAREER CHOICE? THIS PROJECT IS GATHERING NEW PRIMARY RESEARCH DATA ABOUT HOW THE TOTAL ENVIRONMENT—IN AND OUT OF SCHOOL, FROM HIGH SCHOOL THROUGH COMMUNITY COLLEGE AND THE UNIVERSITY—HELPS SHAPE GIRLS' PERCEPTIONS OF IT AS FRIENDLY OR UNFRIENDLY TO WOMEN. THE RESEARCH WILL DOCUMENT THE LONGITUDINAL EFFECT OF FAMILY, PEERS, SCHOOL, AND COMMUNITY ON GIRLS' PERCEPTIONS OF IT CAREERS; EXAMINE THE KEY TRANSITION POINTS IN GIRLS' EXPERIENCES WITH TECHNOLOGY; AND DETERMINE HOW THE CHOICE OF A NONTRADITIONAL CAREER IS ASSOCIATED WITH THE DEVELOPMENT OF SELF-AUTHORSHIP (INVENTING ONESELF).

Standard interview and survey techniques will be combined within the framework of self-authorship, with pre- and post-surveys and interviews with individuals and small groups. The project will prepare a videotape documentary and case studies of the longitudinal development of girls' career choices and transitions. It will develop and use group activities using computer programs to stimulate girls' interest in and understanding of IT careers. It will develop and present IT workshops as an incentive for participating students and parents, as another data collection point, and as a model for exploring IT careers.

The project is an interdisciplinary collaboration among faculty experts in gender and science, in quantitative and qualitative social science research methods, and in how information technology affects children, youth, and families. Project advisers include an expert in how college students' and young adults' self-authorship affects their learning capacity, a former school principal and superintendent, an expert in evaluation and data analysis, an expert in educational technology, the director of a state technology workforce, and a communications researcher.

CODES: E, M, H, U	Virginia Polytechnic Institute and State University
HRD 01-20458 (three-year grant)	
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Keywords: research study, transition points, workshops, career awareness, information technology, video, survey, environmental factors, self-authorship	

OTHER SCIENCES

003
O
Oceanography camp for girls

OCEANOGRAPHY CAMP FOR GIRLS

OCEANOGRAPHY IS INHERENTLY INTERDISCIPLINARY, REQUIRING A FOUNDATION IN MATH AND A FAMILIARITY WITH BIOLOGY, CHEMISTRY, GEOLOGY, AND PHYSICS, FOUR AREAS OF SCIENCE IN WHICH WOMEN ARE OFTEN UNDERREPRESENTED. THE OCEANOGRAPHY CAMP FOR GIRLS ENCOURAGES GIRLS POISED TO ENTER HIGH SCHOOL TO TAKE MORE MATH AND SCIENCE COURSES AND TO CONSIDER THE SCIENCES AS A CAREER OPTION.

Developed jointly by the University of South Florida's Department of Marine Science and the Pinellas County School System, the camp allows girls to apply the knowledge gained from hands-on activities to a tangible marine environment in their own backyard. They accomplish this bridging through field trips, data-collection cruises aboard a research oceanographic vessel, and extensive lab work and problem solving.

The camp, which at first reached only 30 girls in Pinellas County, later expanded to serve 64 girls from middle schools in six counties—selected from an applicant pool of nearly 300. The project targeted girls of all aptitudes who were entering ninth grade, especially girls from ethnic minorities. The initial target audience was girls leaving seventh grade, but feedback suggested that a year more of maturity, responsibility, and science content (in earth, life, and physical sciences) would enable girls entering ninth grade to benefit more from the camp than girls entering eighth grade. About 23 percent of the residential campers and 29 percent of the commuter campers were African American, Hispanic, Asian, and Native American. The most valuable (albeit labor-intensive) tool for selecting participants was interviews, done in person during school hours or by phone after school.

The project tried both commuter and residential camps and found the residential format to be more effective. In residential camps, participants were more willing to be involved during daytime activities, worked more cohesively as a group, and felt more of a sense of camaraderie, engaging in detailed conversations about their camp experiences. Interviews revealed many girls' hesitation about being away from home for three full weeks, so girls went home Friday evenings and returned to camp Sunday evenings.

The three-week camp was held at USF's College of Marine Science, with room and board provided by Eckerd College, a private four-year school with an excellent undergraduate program in marine science. Groups of 10 girls spent a day at sea aboard *Suncoaster*, an oceanographic research vessel, collecting data about Tampa Bay and adjacent coastal waters. They learned about biological and chemical diversity (including mud-dwelling fauna) through a field trip to Fort DeSoto County Park. At Shell Island, they learned about the biological and physical parameters of a protected habitat, learned to paddle a canoe (a peak experience for many first-timers), and discovered how to observe the sensitive marine habitat of mangrove islands. At Caladesi Island State Park, they learned about the physical and geological parameters of the barrier coastline, from waves and currents to dunes and berms. A beach cleanup effort helped them study the human impact on marine life and provide a community service, counting and estimating the amount of trash and recording data for the state census.

Campers also engaged in group lab activities. Using a wax modeling system, they simulated the geophysical processes affecting plate tectonics, created their own fault lines, and collided wax plates to visualize the geophysical processes underlying an earthquake. To learn lab research methodology, they did small-group experiments and problem solving, working with marine science graduates on such topics as geophysics/plate tectonics, computer modeling in oceanography, marine microbiology, zooplankton ecology, coastal geology/beach mapping, satellite oceanography, and seawater chemistry.

Visits to the Florida Department of Environmental Protection, the Clearwater Aquarium (a facility for the statewide rescue and rehabilitation of marine mammals) and the Florida Aquarium added to their knowledge of career options and the academic preparation needed for science careers. One spinoff of visits to local aquariums was a counselor-mediated discussion on the pros and cons of having animals in captivity, of animal rescue and rehabilitation, of educational missions, and of public versus private funding of such undertakings. Ethics-in-science simulation games such as Fish Banks the final week advanced the discussion.

The middle school participants benefited from real-world environmental studies and awareness, from one-on-one mentoring by career professionals, and from interactions with their peers and with returning camp alum, who were role models. In learning about research, academic requirements, and career options, they also learned that their graduate mentors (accomplished scientists) were "cool" and "fun."

"I learned a lot more than I do in science classes in school," said one camper. Getting dirty was part of what made it a great experience, said another. "It was all girls so we were more intent on doing stuff, rather than how we looked."

Positive media stories brought in additional funding, and the oceanography camp, supported by endowments and local private and business donors, continues as a free camp for local girls. Spinoffs included an oceanography workshop for six secondary-level science educators, with hands-on instruction to broaden their ability to teach math and science through ocean sciences; *Project Oceanography*, a live, satellite-televised marine science education program appropriate for middle school students; and "Making Waves," a multimedia approach to learning that offers teachers and students an insider's view of current ocean science research efforts.

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www.marine.usf.edu/girlscamp	HRD 93-53012, HRD 95-52898, HRD 95-54493, (one-year grants)
Partners: Pinellas County (Florida) School System, Eckerd College, United States Geological Survey, Florida Marine Research Institute, and Center for Ocean Technology	
Product: Information on starting a science camp in your area.	
Keywords; demonstration, oceanography, hands-on, field trips, problem-solving skills, minorities, career awareness, role models	

003

jump

Jump start

JUMP START

ALONG FLORIDA'S SOUTHEASTERN "TREASURE COAST," ATTITUDES TOWARD WOMEN ARE STILL VERY TRADITIONAL, AND THE PROPORTION OF WOMEN ENTERING NONTRADITIONAL SCIENCE AND TECHNOLOGY CAREERS IS EVEN LOWER THAN THE DISCOURAGING NATIONAL AVERAGE. MANY YOUNG WOMEN IN THE AREA DROP OUT OF MATH AND SCIENCE BETWEEN HIGH SCHOOL AND THEIR FIRST TERM OF COMMUNITY COLLEGE. IN THIS PROJECT, AN OCEAN SCIENCE RESEARCH ORGANIZATION TEAMED UP WITH A COMMUNITY COLLEGE AND A LOCAL FLORIDA SCHOOL DISTRICT TO ENCOURAGE YOUNG WOMEN'S INTEREST IN SCIENCE CAREERS.

The idea was to provide girls and women with mentors/role models and hands-on science experiences in the transition from middle school to high school and when they enter college, either directly from high school or as re-entrants to academia. Both projects highlighted oceanography and marine science, which are good vehicles for understanding planetary ecology (including global warming), areas with clear potential to help humanity, and hence appealing to women. This was the first time the Harbor Branch Ocean Institute (HBOI) had used—or even recognized the existence of—gender-friendly instructional techniques.

Science and technology careers for women. Over two years, 24 women participated in the pre-college program, more than half of them 30 or older and re-entering college.

Half the participants experienced a classroom-centered module at Indian River Community College (IRCC), which emphasized assessing the students' interests and capabilities, giving them one-on-one opportunities to listen to and interact with women in different scientific and technological careers, and engaging them in activities that exposed them to technical training programs (such as CAD-CAM and industrial design) in the applied science and technology departments. Participants rated this program highly, especially the guest speakers and opportunities to talk with women from various careers.

The other half experienced a highly hands-on module on the HBOI campus, which emphasized active learning experiences in various lab and field settings and opportunities to interact with women in various careers. The women heard presentations, engaged in group discussions, and got direct experience exploring work in marine science, biomedical marine research (discovering drugs from marine sources), museum collections, aquaculture, and ocean engineering.

To stem a 35 percent dropout rate after year 1, material designed to expose students to the scientific method of problem solving was shifted from the IRCC section to the HBOI section, to make the material less formal and potentially intimidating. The re-entry students especially had been daunted by the unfamiliar technical and scientific terminology associated with an experiment they were to conduct and write up in the IRCC section and doubted their abilities.

Participants found the HBOI program valuable, appreciated how enthusiastic and approachable the guest scientists were, and liked the program's experiential nature. They ended up feeling more comfortable with scientific techniques and technologies and more interested in science and technology. In response to an open-ended question about a hypothetical research problem, at the end of the program, all but two of 21 students gave answers that indicated an acceptable level of understanding.

Participants in both programs wished they had had longer class sessions and more hands-on (experiential) learning. Instructors agreed that longer class sessions would allow more complete instruction, training, and discussion of results and observations, improving learning.

None of the HBOI staff had experience working with older, less traditional re-entry students. Dr. Mimi Bres from Prince George's Community College in Maryland conducted a 4.5-hour workshop on understanding and working with adult learners, recommending that they use a highly interactive informal format. One strategy she used was to frequently stop and ask participants to respond to short written questions (both multiple choice and open ended) and follow that up with a facilitated discussion of answers.

Just We Girls. In the summer of 1998, 27 girls entering ninth grade attended Jump-Start Week for Girls (nicknamed Just We Girls), a weeklong summer program HBOI provided in partnership with the St. Lucie County School District. These pre-camp experiences gave girls practical experiences in skill and content areas in which boys typically had more experience than girls: aquarium setup and maintenance, water testing and chemical analysis, specimen collecting, and computer use. The girls also met with women in science.

To test changes in attitude, boys and girls were asked (in pre- and post-tests) to select five out of 15 problems posed and describe how they would approach them. The problems were of three types: "girl" topics (such as "How do I find out what's wrong when my best friend won't speak to me?"), "guy" topics (such as "How do I find out which fishing lure works best?"), and "scientific" questions (such as "How do I determine whether or not a baby sea turtle will head toward the lights on beachfront condos?"). They hoped the girls would have become comfortable enough with the scientific questions to choose more of them on the post-test than they had on the pre-test. They did not find the striking gender differences they expected. Both boys and girls tended to choose "scientific" questions with an environmental theme; they both also tended to prefer labs and outdoor science to classroom science; and girls were more confident about their abilities than expected.

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HRD 97-10971 (one-year grant)	
Partners: Indian River Community College, St. Lucie School District	
Keywords: education program, community college, oceanography, mentoring, role models, hands-on, career awareness, gender differences, self-confidence	

003

aqu

Marine and aquatic mini-camp

MARINE AND AQUATIC MINI-CAMP

GIRLS' SCIENCE EDUCATION OFTEN STOPS AFTER SECONDARY SCHOOL BECAUSE OF THEIR POOR PREPARATION FOR SCIENCE. GIRLS ARE SOCIALIZED AWAY FROM SCIENCE IN MIDDLE SCHOOL, DON'T GET THE EXPLORATORY EXPERIENCES THEY NEED TO DEVELOP AN INTEREST IN SCIENCE, INSTEAD VIEW SCIENCE AS DULL OR DIFFICULT, AND MAY LOSE WHATEVER INTEREST THEY DID HAVE WHEN THEY STUDY IRRELEVANT SCIENCE TOPICS UNDER UNINSPIRING OR POORLY EDUCATED TEACHERS. TO HELP GIRLS BEGIN TO ACHIEVE THE KIND OF SCIENTIFIC LITERACY NEEDED IN A CHANGING JOB MARKET, THE GULF COAST RESEARCH LABORATORY IDENTIFIED 355 GIRLS AT RISK OF DROPPING OUT OF THE SCIENCE PIPELINE AND PROVIDED THEM WITH A HANDS-ON, FIELD-BASED EXPERIENCE IN 12 TWO-DAY RESIDENTIAL MINI-CAMPS.

The Gulf Coast Research Laboratory, administered by the University of Southern Mississippi, is organized in five research groups: aquaculture, fisheries sciences, environmental fate and effects, biodiversity and systematics, and coastal ecology. In groups of 30, students from Mississippi, Alabama, Louisiana, and northwest Florida were introduced to inquiry- and field-based science activities in four areas: oceanography and hydrologic processes, marine and aquatic fauna, marine and aquatic flora, and beach and barrier islands. By improving their perception of science, the project hopes to get more of the participants involved in science.

Factual knowledge alone is insufficient for maintaining the nation's edge in STEM fields. Motivation and inclusiveness are important for sustaining and growing our STEM workforce. This project hoped that giving these students a positive science experience and a chance to see themselves (however briefly) as part of a community of research scientists helped bring about a realistic change in their academic and career aspirations—at least to the extent of enrolling or re-enrolling in high school science courses.

CODE: H	J.L. Scott Marine Education Center and Aquarium, Gulf Coast Research Laboratory
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Keywords: demonstration, hands-on, exploration-based, oceanography, inquiry-based	

003
RLM
REALM: really exploring and learning meteorology

REALM: REALLY EXPLORING AND LEARNING METEOROLOGY

THIS PROJECT FROM FLORIDA STATE UNIVERSITY'S METEOROLOGY DEPARTMENT AND SCIENCE EDUCATION PROGRAM WILL EXPOSE STUDENTS IN 18 MIAMI–DADE COUNTY PUBLIC MIDDLE SCHOOLS TO INQUIRY-BASED METEOROLOGY, AN EARTH SCIENCE OFTEN NEGLECTED IN MIDDLE SCHOOL. BECAUSE THE PROGRAM IS HIGHLY ENGAGING AND IMMEDIATELY APPLICABLE, IT IS EXPECTED TO SIGNIFICANTLY AFFECT THE PARTICIPATION IN SCIENCE OF GIRLS AND THE AREA'S SIZEABLE AFRICAN AMERICAN AND HISPANIC STUDENT POPULATION.

To help reduce girls' attrition from math and science as they move from middle to high school, the project will develop a supportive learning environment, incorporating collaborative learning and staffing labs and tech rooms with women to help make the subject more attractive to girls. Social and artistic factors will be woven into the program because girls find science content more meaningful when it is good for the world, relevant to their everyday world, and connected to subjects like math and art.

Teachers and alternates from the 18 schools will be given two weeks' intensive training to strengthen their knowledge of content and science pedagogy.

Following in part the model of the Oklahoma mesonet, REALM will establish a network of high-quality weather stations that use professional-grade instruments, including wind sensors robust enough to record highly accurate high-resolution data along Florida's "Tornado Alley." Data loggers will be installed at each station and wireless communications will be used to upload data to a central server in Dade County. All 18 schools will have online access to the data, and because NOAA will also make use of the data, NOAA will have a stake in maintaining access to them.

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Partners: FSU's meteorology department and science education program; National Oceanic and Atmospheric Administration; State of Florida Division of Emergency Management	
Keywords: demonstration, parental involvement, meteorology, inquiry-based, African-American, Hispanic, collaborative learning, science clubs, real-life applications	

003
Dig
Girls dig it online

GIRLS DIG IT ONLINE

THIS PROJECT EXPANDS THE INTERNET-ENHANCED LEARNING COMPONENT OF GIRLS DIG IT, A NATIONWIDE GIRLS INC. ARCHAEOLOGY PROGRAM THAT REACHES OUT TO LOW-INCOME GIRLS AND GIRLS OF COLOR IN EARLY ADOLESCENCE (AGES 12 TO 14). THE PROGRAM COMBINES COLLABORATIVE RESEARCH TEAMS AND DISCOVERY-BASED ACTIVITIES THAT TEACH THE PRINCIPLES OF SCIENTIFIC INVESTIGATION WITH ONLINE RESOURCES: AN ELECTRONIC BULLETIN BOARD, AN "ASK THE ARCHAEOLOGISTS" PROGRAM FIELDED BY WOMEN ARCHAEOLOGISTS AND ANTHROPOLOGISTS AT VARIOUS STAGES IN THEIR CAREERS, EXTENDED SEARCHES, LINKS TO "COOL" ARCHAEOLOGICAL RESOURCES, AND A PLACE ON THE WEBSITE WHERE GIRLS CAN PUBLISH EXCAVATION REPORTS.

For the pilot project, six to 12 girls each were selected for four geographically and ethnically diverse sites chosen for their archaeological resources and technological readiness: in Santa Barbara, Cal. (at the site of the Santa Barbara Presidio), in Bloomington, Ind. (a survey and excavation at Lick Creek, site of a 200-year-old African American settlement), in Lynne, Mass. (a simulation of Boston's "Big Dig,"), and in St. Louis, Mo. (a simulated excavation at the White Haven historic site, once the home of Ulysses S. and Julia Dent Grant).

The project's hypotheses—that archaeology would make girls get excited about new technology—was inverted: Girls who had access to Internet technology got excited about archaeology. When the online component was added, many participants who had found the face-to-face program "too much like school" were suddenly quite excited about archaeology—apparently because of their excitement about having access to and support in using online technology. For many girls, the online site—with its accessible and accurate archaeological information—was their first online experience and sometimes their first sustained use of computers.

And the fact that archaeologists study a variety of cultures and rely on physical evidence rather than exclusively on written records ensures that minority participants find themselves represented in the curriculum in ways they may not experience in a typical school curriculum.

Girls used their discussion board extensively, *unlike the program facilitators, who used theirs very little. Staff members were more comfortable getting answers to their questions by phone or e-mail. Unlike the girls, the archaeologists and program facilitators were more comfortable with print than with online documents (including surveys)—unanimously requesting print versions of online materials to use as they viewed the online materials. For adults, online training may be more powerful when conducted in conjunction with face-to-face programs*.

The online/telephone training tested by this project has far-reaching possibilities for implementing programs at distant sites. By using specially created Web pages viewable almost like slides while participants engage in a telephone conference call, training can be delivered at a minimal cost. Face-to-face training can cost as much as $2,000 per participant; telephone-plus-online training may be a cost-effective alternative. But making such training more effective requires certain adjustments: ensuring that call participants find a quiet place to work from, providing print-based materials to supplement online materials, and sending a list of URLs in advance, with instructions on presetting the browser to those pages.

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HRD 99-08759 (ONE-YEAR GRANT)	
KEYWORDS: DEMONSTRATION, WEBSITE, EXPLORATION-BASED, MANUAL, MENTORING, UNDERPRIVILEGED, AFRICAN-AMERICAN; GIRLS, INC., ARCHAEOLOGY, ENGAGEMENT, COLLABORATIVE LEARNING, INTERNSHIPS	

Delivering an Internet-enhanced program creates challenges for youth-servicing organizations. One team, for example, was using computer facilities at a local library, and when they tried e-mailing questions to Ask the Archaeologists, a firewall blocked delivery of the e-mail without alerting the girls that their e-mails went unsent. At another site, the telephone/online staff training could be conducted only in a noisy group office space, seriously compromising the quality of communication.

003
Esys
Earth systems: integrating women's studies

EARTH SYSTEMS: INTEGRATING WOMEN'S STUDIES

HAS THE "MASCULINITY" OF SCIENCE AND SCIENCE EDUCATION KEPT WOMEN, MEN OF COLOR, AND PEOPLE FROM WORKING-CLASS BACKGROUNDS OUT OF SCIENCE COURSES AND SCIENCE CAREERS? HAS SCIENTIFIC INQUIRY AND EDUCATION FAILED TO SITUATE SCIENTIFIC KNOWLEDGE IN ITS SOCIAL AND HISTORICAL CONTEXT? DOES THE SCIENTIFIC ESTABLISHMENT'S INSISTENCE ON THE "PURITY" OF SCIENCE SUPPORT THE CLAIM THAT SCIENTIFIC FINDINGS IMPROVE HUMAN WELFARE?

Earth Systems—the PROMISE project—aimed to create a cooperative, noncompetitive learning environment in which all student voices could be heard and the collaborative production of geological knowledge would be linked to their daily lives through the lens of sociology and feminist theory. Examining the role science plays in shaping definitions of knowledge, power relations, and social inequalities helped students recognize their capacity to act.

In a women's studies classroom, students sit in a circle to decentralize authority. Everyone in the room has a name and a voice, and each is a learner and a potential teacher, contributing to the collaborative construction of knowledge. PROMISE started its earth science course with only a vaguely structured syllabus that would allow for collectively developing course content with the students. Students and teachers alike were immediately made uncomfortable by this departure from traditional education. And while the social science and humanities majors were comfortable sitting in a circle, it made one geology major so uncomfortable she considered dropping the course. In time, everyone became comfortable with the classroom environment and with the "process" method of learning, but in the early days students felt there was too much social context and not enough scientific inquiry. The principal investigators quickly realized *how difficult it was to develop integrated knowledge*.

Not until the last weeks of the course did participants begin to collectively feel the integration of knowledge. They were engaged in an oil-exploration game intended to demonstrate the geological concepts of oil reservoirs and traps. The game was designed to interest students in learning about geology by having them play the role of an independent petroleum company with geologists and economists who needed to make business decisions about where to purchase land and drill for petroleum exploration. But what the students gained was a new understanding of the relationships between natural resources and economic imperatives, as this journal entry shows:

When we first started the game, I had a few unvoiced objections. [I wanted to ask,] what about the environment, ecology, and social consequences of drilling for petroleum? However, these were quickly forgotten as the excitement mounted. Our team wanted to be the first to "strike gold." So we bought information about the land, searched for the best places to drill, bought land, and drilled. We made a profit so we did it again. Soon we were up to $950,000, we were rolling in money and profits were soaring. Could we stop? No! Did I have any reservation about continuing? No. We went absolutely crazy with greed and power. . . . My desire to finish first and make a profit clouded my thinking. Never once did I think about the flora or fauna on top . . . only what was underneath. I looked at risk factors in terms of dollars only, and never once thought of human penalties.

During a weekend excursion into Death Valley to see and experience many of the geological processes and features discussed in class, the students found it easier to understand sedimentary deposits, limestone, sandstone, and basalt, when they were tangible. To reach out and touch rocks that are 1.6 billion years old meant much more than hearing that the rocks existed. On the second day of the field trip, as they entered Mosaic Canyon, they saw faulted, brecciated, polished limestone beautifully displayed in the steep-sided, narrow, curving passage into and through the mountains. They saw how the history and future of a fault cannot be captured by observing a limited rock section. Suddenly and spontaneously, the students began to discuss the unforeseen environmental problems that could result from a spatially limited geological study of a site marked by numerous active faults.

Students began to realize that although we can do little about natural occurrences, we can do something about those who are affected by them. By the end of the course, they had a more complex understanding of the processes that shape scientific inquiry and the uses to which science is put. The project's experience demonstrated that the gap between social and natural sciences can be narrowed.

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HRD 95-55721 (three-year grant)	
Publication: "Feminist Pedagogy, Interdisciplinary Praxis, and Science Education" by Maralee Mayberry and Margaret N. Rees, in National Women's Studies Association Journal, Spring 1997.	
Keywords: demonstration, cooperative learning, sociology, geology, women's studies, feminism	

003

W

Women who walk through time

WOMEN WHO WALK THROUGH TIME

THIS AWARD-WINNING VIDEO WAS DEVELOPED TO SHOW GIRLS AND YOUNG WOMEN THAT EARTH SCIENCE IS A FASCINATING CAREER. "WOMEN WHO WALK THROUGH TIME" SUGGESTS THE IDEA OF WOMEN WALKING THROUGH GEOLOGICAL LAYERS (REPRESENTING TIME) WHILE ENJOYING SUCCESSFUL CAREERS IN EARTH SCIENCE. IT PORTRAYS THREE WOMEN WHO INTRODUCE YOUNG PEOPLE TO THE FIELD, DEMONSTRATE WHAT THEY DO AS EARTH SCIENTISTS, AND ADVISE YOUNG PEOPLE ON HOW TO PREPARE FOR A CAREER IN SCIENCE. THE VIDEO WON A TELLY AWARD FOR HIGH SCHOOL EDUCATION IN 1998.

Earth science is rarely taught in high school, so pre-college students are rarely exposed to earth science mentors of either gender. Few girls are exposed to female role models in the earth sciences or realize the key role geoscientists play in solving environmental problems. Students typically think of science as chemistry, physics, or biology. The video demonstrates earth science's interdisciplinary nature, drawing on math, chemistry, physics, biology, engineering, geography, anthropology, computers—and love of the outdoors.

The 30-minute video is appropriate for students 12 to 18, and older. The allied website features earth science links for girls and young women and information about volcanoes, earthquakes, dinosaurs, minerals, fossils, water, ice, and rock.

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Product: The videotape Women Who Walk Through Time.	
Keywords: dissemination, video, website, earth science, geology, career awareness, role models	

003

ACE

ACES: adventures in computers, engineering and space

ACES: ADVENTURES IN COMPUTERS, ENGINEERING, AND SPACE

THE UNIVERSITY OF TENNESSEE AT CHATTANOOGA, IN PARTNERSHIP WITH GIRLS INC. OF CHATTANOOGA AND THE UTC CHALLENGER CENTER, LAUNCHED ACES TO ENCOURAGE GIRLS TO KEEP STUDYING MATH AND SCIENCE AND TO CONSIDER CAREERS IN SPACE, COMPUTERS, AND ENGINEERING. THE PROGRAM OFFERED 25 MIDDLE SCHOOL GIRLS POSITIVE ROLE MODELS AND POSITIVE HANDS-ON ACTIVITIES,

At a one-week residential summer camp, 25 girls entering seventh and eighth grade are participating in space-related activities at the Challenger Center; hands-on activities in computer science and electrical, mechanical, and industrial engineering; and activities designed to nurture each girl's self-esteem and development as a whole person. Girls Inc. provided leadership for camp counselors, who reduced attitude, behavior, and discipline problems by enforcing rules without alienating the girls.

Engineering activities. *The girls tended to like the hands-on experiments best and the discussion before the activity least*. An industrial engineering activity, for example, introduced systems thinking, product assembly, workstation design, and quality management. Using Lego ZNAP materials (similar to K'nex) and working in teams of six or seven, the girls designed their own assembly environment to build a boat or an airplane. Teams structured themselves to have one inventory person, assemblers (who determined whether to emulate craft, factory, or mass production, introduced through a short lecture on production systems), and a quality person. Teams competed on time to complete each unit, number of units completed within the allotted time, and number of units without quality faults.

An electrical engineering activity familiarized the girls with common circuit elements, circuit schematics, and Ohm's and Kirchoff's laws. In an environmental engineering session, the girls discussed how pollutants and particulates suspended in air reduce visibility and can alter the absorption, scattering, and reflection of colors perceived by the human eye to make up visible light. In a robotic activity—using Lego Mindstorm robotic materials, including a programmable "brick" preprogrammed to drive two motors and a light—students in groups of two designed and built a vehicle that would go forward, stop, turn on a light bulb, spin on one wheel, play an engineering song, and return.

In a mechanical engineering session, teams of two to three girls built experimental bridges using strips of paper, books of like thickness, small paper cups, and pennies. In a civil engineering activity the last night of camp, girls built towers out of standard drinking straws, competing as teams to build the tallest tower that would support a tennis ball for at least 30 seconds. They were given 50 straws, a roll of masking tape, a pair of scissors and a set of instructions about what they could and could not do, in what time frame. In retrospect, the team leaders thought it would be good to start with a slide presentation to help the girls visualize structure building and triangulation.

Computer activities. *The girls liked having something to take home to show their family and friends*. Hands-on experiences with computers, using gender-neutral software, allowed the girls to develop Web pages that reflected their interests, to do simple programming (building a basic user interface form for a program to play Hangman), and to use computer-assisted design (CAD) software—for example, to study perspective using a Lego block from robotics.

Space-related activities. More than three dozen nonprofit, informal Challenger science education centers opened after the 1986 space shuttle tragedy. For this project, the UTC Challenger Center provided student-based space mission simulation programs to reinforce and introduce students to real-world applications of science principles and concepts discussed in their classrooms. Activities included a Mission to Mars activity, with Team A at mission control and Team B "traveling" via a shuttle simulation to a space station on Mars; the design, construction, launching, and testing of rockets, using plastic soda bottles, glue, tape, and construction paper; and the design and construction of a space station on land and under water, using a large container of Quadro (buoyant material similar to PVC) containing various types and sizes of extensions and connectors.

Lightening or varying the mix of camp activities were ice breakers to help the girls get to know each other, craft sessions, team-building activities, and interactions with *role models, who learned the importance of visual aids, to help the girls visualize what they do*. Follow-up activities for the school year involved computer science, product design (the popular design and construction of a container/device to protect eggs from a 3-story drop), industrial engineering, the Discovery Museum, and a field trip. An ACES Fair—featuring hands-on engineering, computer, and space activities—was to be held at selected elementary, middle, and high schools and community centers.

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PARTNERS: GIRLS, INC. AND THE UTC CHALLENGER CENTER	
KEYWORDS: DEMONSTRATION, HANDS-ON, ROLE MODELS, INFORMAL EDUCATION, CAREER AWARENESS, ENGINEERING, COMPUTER SCIENCE, SPACE, FIELD TRIPS	

003

wild

Careers in wildlife science

CAREERS IN WILDLIFE SCIENCE

WHETHER DISSECTING OWL PELLETS, LEARNING ABOUT EDUCATIONAL REQUIREMENTS FOR BECOMING A VETERINARIAN, TEACHING YOUNGER GIRLS HOW ANIMALS COMMUNICATE, OR HELPING HERD FLAMINGOS AT THE BRONX ZOO, THE GIRLS IN THE THREE-YEAR WILDLIFE SCIENCE CAREERS (WSC) PROGRAM ARE BEING EXPOSED TO CAREER OPPORTUNITIES FOR WOMEN IN WILDLIFE SCIENCE.

Using hands-on learning and girls' natural interest in animals, the Wildlife Conservation Society's three-year WSC program promotes enthusiasm for the basic sciences and for careers in wildlife science. Each year, the program recruits 105 Girl Scouts, aged 12 to 14, from the inner city of New York City's five boroughs. It also trains 12 to 15 Girl Scout leaders and parents as leader–mentors, to help with the program and to share information about the Bronx Zoo and wildlife sciences with others in their troops.

As part of the program, each year Cadette and Senior Girl Scouts (aged 12 to 14) attend a three-day winter career workshop at the Bronx Zoo, which gives them an entirely different perspective from their daily urban environment. The zoo—a verdant oasis in the midst of seemingly endless urban sprawl—gives many Girl Scouts their first-ever experience with plants and animals.

Instructors from the zoo's education department give the girls a behind-the-scenes look at various animal exhibits and teach them about different animals' needs, habitats, and behaviors. Girls learn to use scientific equipment such as microscopes, binoculars, range finders, and radio tracking units. They speak with women professionals at the zoo, learning firsthand about careers in conservation (such as primatologist, ornithologist, wild animal keeper, veterinary technician, lab supervisor, media archivist, and field biologist). At a career fair, participants present projects featuring the six clusters of wildlife-related careers: animal care and management, education, exhibit design, field science, wildlife health, and wildlife science park support. The workshops culminate in an overnight at the zoo, where girls eat dinner, observe the habits of nocturnal animals on a night hike, and participate in a wildlife scavenger hunt.

The girls also participate in field experiences at WCS's other living institutions. At the New York Aquarium, they learn about the differences between aquatic and terrestrial animals and go behind the scenes with dolphin trainers. They hit the beach at Coney Island for a hands-on demonstration of plankton sampling. At the Prospect Park Zoo, they practice common field methods used to study primates in the wild. At the Queens Zoo, they learn about domestic and farm animal care and visit a unique bird feeding station in the marsh exhibit.

Before the winter workshops, Girl Scout leaders receive training in leadership and mentoring, gender equity issues, and the importance of wildlife-related careers. Girls 14 to 17 who are interested in developing leadership skills can get training as program aides, helping troop leaders with meetings of younger Girl Scouts and sharing what they have learned about wildlife science. In 2000, WCS trained more than 80 girls as aides. This train-the-trainers model will extend the program's impact.

Girls who have completed aide training and service are eligible for the competitive WSC internships at one of the five New York WSC parks (those mentioned plus the Central Park Zoo and the St. Catherines Wildlife Survival Center), where they are carefully matched with a mentor–supervisor and get work experience, mentoring, and a modest stipend. More than two dozen young women have served as interns, working with professionals in such fields as herpetology, ornithology, publishing, wildlife nutrition, and veterinary pathology.

This project offers inner-city girls an opportunity to learn about fields unknown to them and to experience professional/technical activities firsthand. Their first reaction is to reach out and touch the animals. After being at the zoo and interacting with role models, they become interested in the many kinds of opportunities available at the zoo.

CODES: M, H, I, PD	WILDLIFE CONSERVATION SOCIETY
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www.wcs.org	HRD 96-31959 (ONE-YEAR GRANT) AND HRD 97-14791 (THREE-YEAR GRANT)
PARTNERS: BRONX ZOO, GIRL SCOUT COUNCIL OF GREATER NEW YORK	
KEYWORDS: DEMONSTRATION, CAREER AWARENESS, GIRL SCOUTS, TRAINER TRAINING, FIELD TRIPS, HANDS-ON, WILDLIFE SCIENCE, INTERNSHIPS, MENTORING, GENDER EQUITY AWARENESS, ROLE MODELS, INFORMAL EDUCATION	

003
binfo
Bioinformatics for high school

BIOINFORMATICS FOR HIGH SCHOOL

BIOLOGY IS QUICKLY BECOMING AN INFORMATION-DRIVEN SCIENCE, AND THE INTEGRATION OF INFORMATION TECHNOLOGY AND MOLECULAR BIOLOGY HAS CREATED A NEW DISCIPLINE: BIOINFORMATICS. THE ANALYSIS OF DATA ABOUT MOLECULAR SEQUENCES IS CHANGING NOT ONLY THE WAYS BIOLOGISTS APPROACH PROBLEMS BUT THE VERY QUESTIONS THEY ASK—ESPECIALLY ABOUT HOW SCIENTISTS CAN USE THE DATA BECOMING AVAILABLE FROM THE HUMAN GENOME PROJECT AND OTHER DNA DATABASES.

With this project, Immaculata College offered a summer enrichment program on bioinformatics for 16 girls entering senior year of high school. The project targeted minorities and other student groups underrepresented in STEM, from the greater Philadelphia area, including counties in nearby Delaware and New Jersey

In the five-week residential program, students learned about molecular biology, including genetic diseases and evolutionary classification; computer technology, incorporating bioinformatics tools; group processing techniques; and related legal and ethical issues. Guided by educators, students working in problem-based learning groups learned the concepts and gathered the information needed to solve real problems. They used the NSF-funded program Biology Student Workbench, a Web-based computational interface for analyzing genetic data.

Women from industry, government, and education spoke to them, and they took field trips to a science museum, a pharmaceutical company, a university laboratory, the National Institutes of Health, and the Institute for Genomic Research Sequencing Center.

While a fair number of women choose biology as a career, fewer choose computer-related careers. This program was designed to encourage girls interested in biology to consider bioinformatics as a field of study and a profession. When the summer program ended, the students gave presentations in their high school science classrooms and clubs, demonstrating their confidence in what they have mastered and serving as role models for their classmates. At a fall reunion, they shared their peers' responses. The program directors stay in touch with the girls and work with BioQUEST and the Biology Student WorkBench team to encourage replication of the program at other sites nationwide.

CODES: U, H	Immaculata College
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www.immaculata.edu/Bioinformatics/	HRD 00-86360 (one-year grant)
Keywords: demonstration, bioinformatics, biology, information technology, summer program, problem-based, field trips, role models	

003
life
Life science biographies

LIFE SCIENCE BIOGRAPHIES

THE AMERICAN PHYSIOLOGICAL SOCIETY (APS) DEVELOPED CURRICULUM MATERIALS TO HELP SECONDARY SCHOOL BIOLOGY TEACHERS ACQUAINT MIDDLE AND HIGH SCHOOL STUDENTS WITH 20 WOMEN IN SCIENCE AND WITH THE INQUIRY APPROACH TO SCIENCE ACTIVITIES. THE APS DEVELOPED, REVIEWED, AND FIELD-TESTED 20 LEARNING MODULES THAT CAN BE DROPPED INTO LIFE SCIENCE CURRICULA, COORDINATING THEM WITH CURRICULAR GOALS AND PROPOSED NATIONAL STANDARDS FOR INTRODUCTORY BIOLOGY.

Published in one volume as *Women Life Scientists: Past, Present, and Future—Connecting Role Models in the Classroom Curriculum*, these biographies will help middle school life science students and high school biology students view science as an exploratory activity done by real people, including women of color and women with disabilities.

Scientists in physiology, medicine, and public health are physiologist Kim Barrett, reproductive physiologist Betsy Dresser, cardiovascular physiologist Joyce Jones, medical researcher Maria Mayorga, microbiologist Judith Pachciarz, public health physician Sara J. Baker, and AIDS researcher Linda Laubenstein. Betsy Dresser, for example, helps preserve endangered species through in vitro fertilization and embryo transfer. In the Dresser unit, student groups debate the relative merits of preserving endangered species through conservation or through embryo transfer. Sara J. Baker, best known for helping track down Typhoid Mary, reformed public health in the early 1900s. In the Baker unit, students must develop an action plan for tracking down the source of a present-day typhoid epidemic before it becomes widespread.

Scientists in ecology, botany, and animal behavior are behavioral ecologist Jennifer Clarke, marine biologist Sylvia Earle, behavioral ecologist Deborah Gordon, ecologist Rachel Carson, animal behaviorist Dian Fossey, botanist Ynez Mexia, and naturalist Beatrix Potter.

Scientists in molecular biology, biochemistry, genetics, and microbiology are microbiologist/molecular geneticist Alice Huang, molecular virologist Marian Johnson-Thompson, geneticist Mary-Claire King, biochemist and molecular biologist Lambratu Rahman, biohemist Gerty Cori and geneticist Barbara McClintock.

Each module includes a brief biography of a woman of science followed by hands-on (inquiry-based or problem-solving) activities related to the work of the woman profiled. The modules were field-tested with students in middle and high school and community college classrooms and with teachers during workshops held at meetings of the National Science Teachers Association and the National Association of Biology Teachers. These teachers concluded that the units would be appropriate for many ages but especially for students in grades 7–12.

CODES: M, H, I	American Physiological Society
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www.faseb.org/aps and www.the-aps.org/education/k-12misc/ord-wls.htm	HRD 93-53760 (one-year grant)
Publications: Women Life Scientists: Past, Present, and Future (Matyas and Haley-Oliphant, 1997).	
Keywords; demonstration, biology, curriculum, biographies, hands-on, life sciences, inquiry-based	

003

pol

Apprenticeships in science policy

APPRENTICESHIPS IN SCIENCE POLICY

WOMEN TEND TO COME LATE TO THEIR UNDERGRADUATE MAJORS, OFTEN CHANGING MAJORS SEVERAL TIMES AFTER ARRIVING AT COLLEGE. THIS TENDENCY TO DECIDE LATE ON A MAJOR IS ONE REASON MANY WOMEN DROP OUT OF MATH AND SCIENCE, BUT IT COULD ALSO BE ONE WAY THEY ARE DRAWN INTO STEM. WOMEN WHO LEAVE SCIENCE EXPLAIN THAT THEY SEE MOST MATH AND SCIENCE COURSES (EXCEPT FOR PRE-MED) AS NOT BEING PEOPLE-ORIENTED. AMERICAN UNIVERSITY (AU) DESIGNED THIS PROJECT—*A SPRING SEMINAR ON SCIENCE POLICY FOLLOWED BY A SUMMER RESEARCH INTERNSHIP*—*TO ALTER THAT NARROW VIEW OF SCIENTISTS AS ISOLATED RESEARCHERS, WORKING ALONE, DEALING WITH CONCEPTS BUT NOT PEOPLE*.

The spring seminar on science policy included discussions of science ethics, the environment, space policy, justice, statistics, the information age, and such applications of chemistry and biology as cloning, DNA work, and mad cow disease. The project brought in AU faculty as well as speakers from government and nonprofit organizations working on science and science policy. Students were offered special computer training, especially in the use of databases and statistical software. Each student wrote three papers and participated in a group project.

They then worked fulltime in NSF-funded summer internships in science policy in government, industry, or nonprofit organizations. They were housed together in AU dormitories so they could share experiences.

Several students changed to math or science majors as a result of the project, and others registered for more math and science courses. (AU's math department had already had some success persuading women to select statistics or applied statistics as a second major after they took the one statistics course required for their majors in the social sciences.) Final results won't be known until the students graduate, go to graduate school, or take up their careers. But even if they don't pursue careers in math or science, they will have a better appreciation of how important a solid knowledge of math and science is to concerned citizens and to public servants formulating policy about health, education, the environment, defense, and other critical issues.

CODE: U	American University
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HRD 96-32086 (one-year grant)	
Keywords: demonstration, science policy, internships, research experience, computer skills	

003

H_2O

Splash: the math and pshysics of water

SPLASH: THE MATH AND PHYSICS OF WATER

THIS ACTIVITY- AND TEAM-BASED MODEL PROJECT FOR EIGHTH GRADE GIRLS EXTENDED AND ENHANCED AN NSF-FUNDED FOUR-WEEK SUMMER CAMP (SUMMER SCIENCE SPLASH) THAT IN 1993 HAD SERVED 50 OF THE SAME GIRLS: *ABLE, WELL-MOTIVATED MINORITY STUDENTS WHO, WITHOUT SPECIAL ATTENTION, WERE LIKELY TO LOSE INTEREST IN SCIENCE AND MATH.*

In camp, the students used group discussions, experimentation, and fieldwork to learn about water's physical properties and role in the Northwest ecology, the principles of waves, and issues of water quality. The project provided for 25 of the campers, building on knowledge and skills gained in the camp, to carry out a challenging science project on a water-related issue (for example, stream monitoring, hydroelectric power, and water in weather, avalanches, and marine biology). Teams of two to five students—plus a middle school teacher, a professional mentor, and a Seattle University undergraduate mentor—worked on the science projects together. *The idea was that academic-year reinforcement of the excitement generated by the camp would heighten many students' continuing interest in science*.

The 25 students read, did field work, experimented, held team discussions, built models, and wrote. A curriculum designer helped the teams design projects that were significant but appropriate for the time frame (five months). The students spent time learning about science, interacted with scientists as friends and role models, and gained skills in leadership, teamwork, presentations, and project management. They appreciated being part of a program that stressed cooperation more than competition.

Two students taught a unit on whales in an elementary class. Several teams did stream restoration projects on Bear Creek and North Creek. A team of Native American students took an elementary class on a stream monitoring expedition. One group learned about fractals, programming a IIgs computer and playing a game called Chaos, first with dice and then with the TI-81 graphing calculator, using random numbers. (If the game Chaos is played long enough, the Sierpinski triangle always emerges—an application of the law of large numbers.) One team mentored students at First Place (a school for children who live in shelters), teaching them about Lego-Logo—creating Lego machines, using Lego toys, and instructing a computer to operate them. Other teams studied the space shuttle *Challenger* and how comets travel in space; studied avalanches and went to Snoqualmie Pass to gather data on avalanche conditions; built a model sailboat and tested various sail positions; learned how to use ultrasound; and edited a videotape explaining the entire project. One student won a national award for testing airfoils on a model wind tunnel. Many students were featured on TV or radio and in newspaper and magazine articles.

CODE: M	Seattle University
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HRD 93-53804 (one-year grant)	
Partner: Native American Heritage School	
Keywords: demonstration, activity-based, teamwork approach, water, ecology, hands-on, math, physics, mentoring, role models	

ENGAGED LEARNING: INVESTIGATING WATER QUALITY

AT A FOUR-WEEK SUMMER SCIENCE CAMP HELD AT SOUTHERN ILLINOIS UNIVERSITY AT EDWARDSVILLE, HIGH SCHOOL STUDENTS WERE IMMERSED IN RESEARCH ABOUT A SUBJECT OF REAL-LIFE CONCERN—THE WATER QUALITY OF OUR RIVERS AND STREAMS—AND LEARNED ABOUT MATH, PHYSICS, CHEMISTRY, AND ENGINEERING CONCEPTS ON A NEED-TO-KNOW BASIS. THE IDEA BEHIND THIS EXPERIMENT IN "ENGAGED LEARNING" WAS TO MOTIVATE STUDENTS TO LEARN THE SKILLS AND BACKGROUND NEEDED TO COLLECT, ANALYZE, AND INTERPRET DATA.

003

inv

Engaged learning: investigating water quality

Under the direction of university faculty, and using labs and equipment not available to them in high schools, the students engaged in empirical research about water quality. To prepare for collecting and analyzing data, students were guided to understand the meaning of accuracy, reliability, replicability of experimental results, and sources of error. They learned about standard deviation, percentage-precision error, average deviation, and rejection quotients, as they relate to accuracy. Math instruction emphasized functions (a key to success in calculus) and the relationship between functional form and the shape of a graph. Students manipulated data on computers to fit curves to the data, producing graphical output, algebraic functions, and correlation statistics.

In an introduction to environmental engineering and wastewater treatment—using math, physics, and chemistry—the students addressed a request for proposal (RFP) from an entity that wanted residential wastewater treated.

CODES: H, U	SOUTHERN ILLINOIS UNIVERSITY AT EDWARDSVILLE
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HRD 99-08734 (ONE-YEAR GRANT)	
KEYWORDS: DEMONSTRATION, RESEARCH EXPERIENCE, WATER, SUMMER CAMP, ENGINEERING, ENGAGED LEARNING	

They investigated the properties of campus pond water and analyzed its quality, measuring the water for pH, turbidity, total solids, dissolve oxygen, nitrates, phosphates, biochemical oxygen demand, temperature change, and fecal coliform.

003
img
Women's images of science and engineering

WOMEN'S IMAGES OF SCIENCE AND ENGINEERING

HANDS-ON EXPERIENCES WITH STATE-OF-THE-ART IMAGING TECHNOLOGY SERVED AS THE MAGNET TO DRAW FEMALE STUDENTS (AND THEIR TEACHERS) TO THIS PROJECT FROM ARIZONA MIDDLE SCHOOLS, HIGH SCHOOLS, AND COMMUNITY COLLEGES. BY EXPERIENCING HOW SCIENTISTS AND ENGINEERS EXPLORE THE STRUCTURE, PROPERTIES, AND FUNCTIONS OF MATERIALS, PARTICIPANTS WERE BETTER ABLE TO UNDERSTAND CONCEPTS OF PHYSICS, CHEMISTRY, AND BIOLOGY AT THE ATOMIC LEVEL.

Students were able to look through telescopes and charge couple detectors (which make objects appear closer) to see objects in the sky typically studied by astronomers; through magnifying glasses and surveyors' transits at objects the human eye can measure; through optical microscopes and videoscopes at objects too small to be seen unaided; through the electron microscope at submicroscopic objects (smaller than a wavelength of light), such as viruses; and through a scanning tunneling microscope and a transmission electron microscope at nanometer-scale landscapes on the same common objects.

WISE days (women's images of science and engineering) were held Saturdays for middle and high school girls and Fridays for community college students. Cross-discipline activities (e.g., apples, red blood cells, and integrated circuits) gave pre-college students a chance to use microscopy to examine everyday items or items of high interest. The most popular WISE day, on forensic science (crime lab, DNA, murder mystery, fingerprinting—and a pathologist's presentation), became a teacher-driven module the third year; mining and air pollution (acid rain) were also popular. Project-based learning activities for community college students emphasized Web-based research and how to develop Web pages to display project results.

Family nights, held roughly once a month on Friday evenings, sometimes offered hands-on exhibits and activities, sometimes presentations (for example, on "Rainbows, Soap Bubbles, and Peacock Feathers," on iridescence, or a night at the ASU planetarium).

Summer workshops for students and teachers used presentations, guest speakers, group activities, role playing, hands-on lab activities, and journals to cover a range of topics, from women in science and Web page construction to scaling (microscopes to telescopes), photosynthesis, superconductivity, scanning probe microscopy, and high-resolution electron microscopy. Teachers were paid stipends and encouraged to participate in activities for students. At their request, teachers were also given separate two-day, six-hour faculty workshops.

Students and teachers alike preferred hands-on, inquiry-based activities using the various imaging technologies, but they also rated highly a river rafting trip and Web page construction. Of students who participated, 60 percent said they were now more likely to take advanced math and science courses.

CODES: M, H, U, I, PD	MARICOPA COUNTY COMMUNITY COLLEGES
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HRD 95-55733 (THREE-YEAR GRANT)	
PARTNERS: CHANDLER-GILBERT COMMUNITY COLLEGE, WILLIS JUNIOR HIGH SCHOOL, ARIZONA STATE UNIVERSITY (AND PLANETARIUM), ARIZONA SCIENCE CENTER.	
KEYWORDS: DEMONSTRATION, COMMUNITY COLLEGE, HANDS-ON, WORKSHOPS, PARENTAL INVOLVEMENT, PROJECT-BASED, TEACHER TRAINING, INQUIRY-BASED, FIELD TRIPS	