Patching the leaky pipeline
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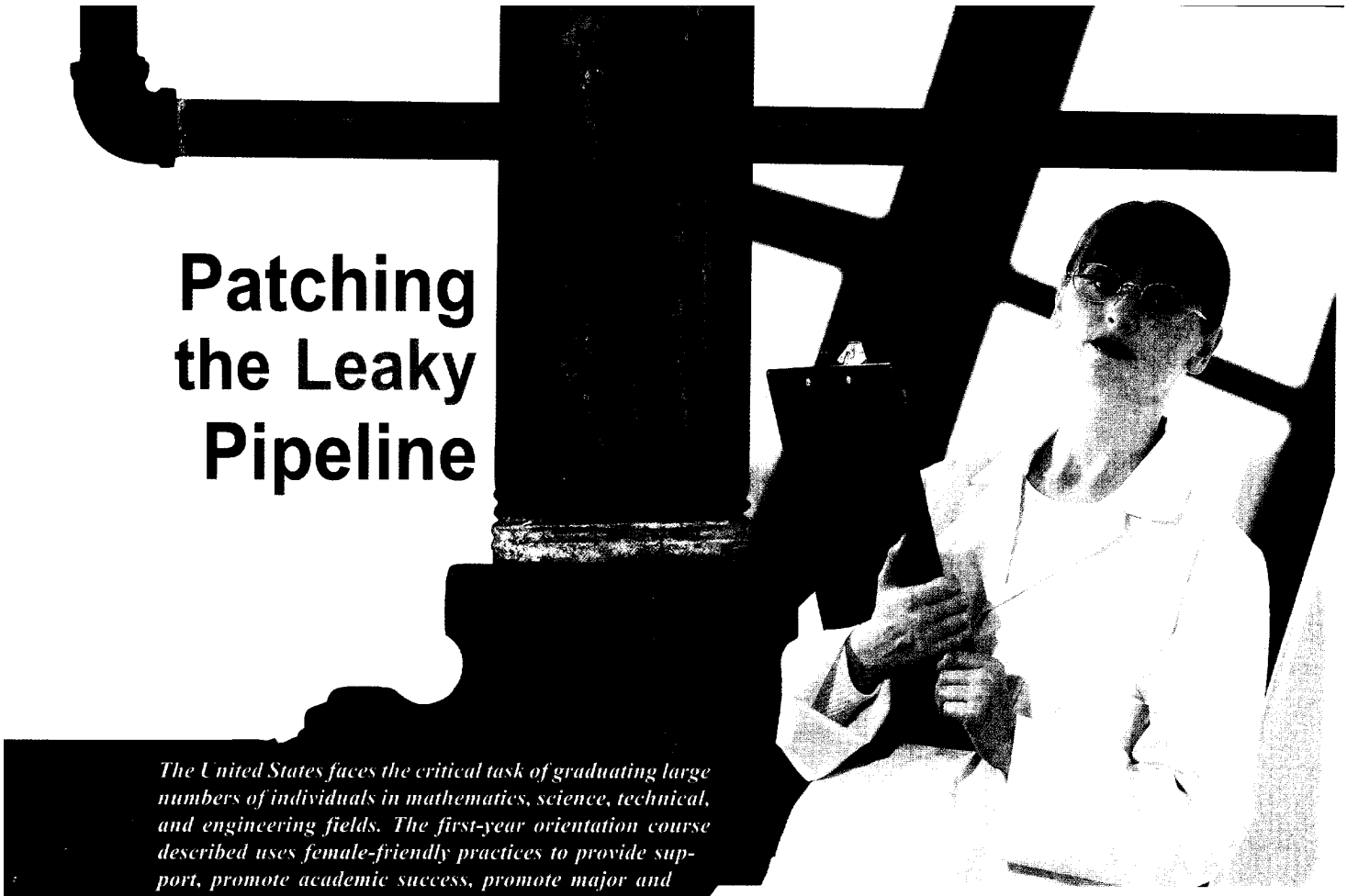

Patching the Leaky Pipeline

The United States faces the critical task of graduating large numbers of individuals in mathematics, science, technical, and engineering fields. The first-year orientation course described uses female-friendly practices to provide support, promote academic success, promote major and career development in an MSTE field, and facilitate consideration of issues faced by women in undergraduate science majors.

Keeping First-Year College Women Interested in Science

Andrea M. Atkin, Ruth Green, and Laura McLaughlin

To maintain its leadership in science and technology and remain competitive in the world economy, the United States must continue to graduate large numbers of individuals in mathematics, science, technology, and engineering (MSTE) fields.

Since the early 1980s, scientists and the public have become increasingly concerned about problems related to science teaching (Rosser 1997; Astin and Astin 1993; Seymour and Hewitt 1997) and the declining numbers of American scientists being trained in the United States. Two significant problems are the declining rates at which U.S. college students enroll in and complete MSTE degrees and the low participation and success rates for women in MSTE fields (AAUW 1992).

The process by which individuals enter, progress through, and leave MSTE educational programs and science and engineering careers is often likened to a pipeline (Berryman 1983). During the college years, the pipeline is very "leaky." Cooperative Institutional Research Program data show that 40 percent of all students who enter college with an interest in mathematics, science, and engineering majors leave these majors between their first and second years (Astin and Astin 1993).

The pipeline is even leakier for women. Compared to men, women experience lower levels of access, participation, success, and completion in MSTE academic majors and careers (NSF 1996; Doolittle 1996). For example, during the 1994–95 school year, more women than men enrolled in college, but fewer women than men sought MSTE college majors (Digest of Educational Statistics 1997). Also, in selected MSTE fields, women earned fewer degrees than men at all levels (Table 1).

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ferences in ability, contribute to the existing college-level gender gap in MSTE participation and success. By the time they enter college, women have experienced lower parental (Eccles and Jacobs 1986; Maccoby and Jacklin 1974; Fox and Tobin 1980) and teacher (Sadker and Sadker 1986; Morse and Handley 1985; Becker 1981; Hallinan and Sorenson 1987) expectations and encouragement related to MSTE par-

The leaky pipeline continues into the workplace. At the postsecondary level, women are underrepresented among those teaching in MSTE fields. Thirty percent of all instructional faculty in institutions of higher education are female. And many fields still have few female faculty members. For example, only 2 percent of the faculty in physics and engineering are female (Digest of Educational Statistics 1997). Outside of academia, women in the United States represent 52 percent of the population and 50 percent of the total work force, but only 15 percent of the employed science and engineering work force (NSF 1996).

Faced with these statistics, the scientific and educational communities have worked to increase women's access to and success in MSTE fields (Astin and Astin 1993; Seymour and Hewitt 1997; Tobias 1990, 1992). Initial reform efforts focused on identifying differences in attitudes and skills between men and women and strengthening women's perceived deficiencies (e.g., improving visuospatial skills, assertiveness training, and participation in competitive sports).

Results from this early research indicate that differential precollege experiences for boys and girls, rather than dif-

Table 1. ***Percentages of Men and Women Earning Degrees in Selected Fields in 1994–95. (Source: Digest of Educational Statistics, U.S. Department of Education, Washington, D.C.: 1997, pp. 305–320).***

Field	Bachelors		Masters		Doctoral	
	Men	Women	Men	Women	Men	Women
Biological and life sciences	48%	52%	48%	52%	60%	40%
Business	52%	48%	63%	37%	73%	27%
Computer and info. sciences	72%	28%	74%	26%	82%	18%
Education	24%	76%	24%	76%	38%	62%
Engineering	72%	28%	74%	26%	82%	18%
Mathematics	53%	47%	61%	39%	78%	22%
Physical sciences	65%	35%	70%	30%	76%	24%
Psychology	27%	73%	28%	72%	14%	86%
Social sciences and history	54%	46%	56%	44%	64%	36%

ticipation and achievement, greater peer pressure to choose a nonscience major or career (Crowley and Shapiro 1982; Hanson and Ginsburg 1988), and teacher biases in science-related courses at all levels (Oakes 1990; Fox, Brody, and Tobin 1985). Women also have less experience with scientific observations, instruments, and activities and have taken fewer and lower levels of mathematics and science courses (Matyas 1985; Oakes 1990; Fennema and Peterson 1985). Women generally have had few science-related female role models (Charles 1992; Cole 1987; Rossiter 1982) and experience lower levels of confidence and self esteem related to science achievement (Astin and Astin 1993; Linn and Hyde 1989).

Given these findings, subsequent research and programmatic efforts have been shifted from identifying female deficiencies to identifying and developing organizational structures and classroom practices that enhance female access and success in science-related endeavors (Nelson 1996; Project Kaleidoscope 1994; Treisman 1985; Nair and Majetich 1995; Hynes 1989; Sandler 1993; Harding 1986; Adler 1984; Tobias 1992; Milem and Astin 1993). This article describes one program based on such practices. This one-credit orientation course in a first-year experience program helps female students explore MSTE majors and careers and develop the attitudes and skills needed to be successful.

Figure 1. ***First-Year Program Student Learning Experiences*.***

Orientation Course
- Learning styles
- Goal setting
- Personal values
- Work values
- Interests
- Personality types
- Personal mission statement

Intensive Advising
- Advising contacts (36–40 per year)
- Advisors in residence

Cocurricular Programming
- FYC convocation
- Residence hall activities
- Faculty fellows program
- Networking
- Night owl meals
- Partnerships with counseling campus ministry

Major/Career Exploration
- Open house
- Career panels
- Career planning workshops
- Academic networks
- Career computer searches
- Career portfolio

Academic Emphasis
- Academic skills workshop
- Academic mentors
- Tutors in residence hall
- Advising sessions
- Checks on grades
- Four-year graduation plan

* This table lists activities by programmatic area. There is overlap among programmatic areas, and the orientation course serves as an organizing mechanism for the activities.

MSTE Course and Students

The following MSTE course is part of a comprehensive first-year experience program (FYP) at a large, research I, land-grant university best known for its technical programs. The FYP serves approximately 800 first-year students (approximately 25 percent of the entering freshman class), the majority of whom are uncertain about their choice of major or career direction. These students leave this program after two or three semesters and matriculate into a major in one of the university's constituent colleges. The FYP provides students with a comprehensive program that incorporates intensive individual advising, a two-semester, one-credit orientation course, an academic emphasis, cocurricular programming, and opportunities for major/career exploration (see Figure 1).

In the fall of 1998, 38 women who were enrolled in the FYP and wished to consider MSTE majors and careers were assigned to one of two MSTE course sections. The MSTE section is designed to help first-year women acquire a realistic, optimistic picture of being female in a MSTE major or career and help them acquire the attitudes and skills needed to be academically and professionally successful.

The MSTE course intends to help women sustain their interest in MSTE majors and careers, understand the MSTE academic environment, and strengthen their coping skills so that they will enroll in and graduate from MSTE majors. The course focuses strongly on issues relevant to women in MSTE majors and careers, such as helping students understand the barriers they may encounter in MSTE settings, providing information about MSTE majors and careers, offering opportunities to interact with women working in science-related careers, and exploring ways in which being a woman can influence career decision making. Figure 2 provides an overview of the goals and specific learning activities for the MSTE course.

This course offers activities that are centered on the course goals and promote the cognitive and personal development of the students enrolled—especially inquiry, self-reflection, and critical thinking. The fall semester focuses more strongly on transition issues, whereas the spring semester emphasizes major and career exploration. Of particular importance are the spring semester capstone projects, which require students to reflect on and synthesize their experiences over the course of the year and integrate them into their expectations and goals as students and professionals in MSTE fields. (For a listing of the weekly activities, go to

JCST's website at *www.nsta.org/college.*)

MSTE Course Description

This section describes the activities in which students in the MSTE course participate, grouping the activities by goals (Figure 2). However, all activities in the course necessarily address more than one goal at a time. For instance, the guest panelists speak about MSTE majors and careers, but they also serve as role models in MSTE, thus addressing the goals of support, integration, gender identity, and decision making.

Support and Integration

In several ways, the structure of the course helps integrate students into the university and the MSTE community and support female students in their aspirations toward MSTE majors and careers. First, the orientation classes are small (limited to 23 students). Second, enrollment is limited to female students who express interest in MSTE majors and careers. Third, the course is designed to ensure that students actively participate in considering relevant issues and that their opinions are heard and respected by the instructors and the other students.

The small size and homogeneity of the class and the active student participation allow students to get to know each other. Students have a safe space in which to speak and won't be treated differently—as may be the case in coed classrooms. The female students also do not stand out as peculiar for their interest and ability in MSTE. Additionally, being in an all-female classroom on a campus with a student body that is 60 percent male creates a heightened sense of gender awareness and affirms that the women are not alone in their MSTE interests, abilities, and concerns.

It is widely accepted that a relationship with a caring adult within the university promotes academic success and helps students feel integrated into the university community. Students in each MSTE section are team taught by two instructors, one of whom is also their academic adviser. Students work with their adviser once each week in the classroom (15 or 16 times each semester) and regularly meet one-on-one. Because the course runs a full year, students tend to know and form stronger bonds with each other and with the adviser.

Course activities also contribute to the support and integration of the students. The online forum, for example, allows students to discuss issues and events from the MSTE course with their classmates in both sections of the MSTE course. These web discussions show the students that their peers have the same hopes and fears and give them an opportunity to interact with and encourage each other.

Figure 2. *Goals of MSTE Cases with Supporting Activities*

Support/Integration
- Small, supportive class
- Intensive advising relationship
- Socioacademic groups (math/science)
- Computerized listserv for class members
- Required cocurricular activities
- Relationships (general transition to college)
- Wellness issues

Academic Success
- Academic skills
- Networking with MSTE women
- Self as learner in MSTE
- Campus resources
- Summer reading

MSTE Major/Career Development
- Majors fair, academic networking, career panels
- Self assessment (SII, MBTI, Holland code)
- Guest speakers/role models in MSTE—faculty, student, and professional
- Comprehensive career paper
- Cooperative education opportunities
- Web forum online discussions

Gender Identity and Decision Making
- Feminist pedagogy and perspectives
- Discussion of misperceptions about MSTE and gender
- Reading/writing assignments
- Opportunities for guided reflection
- Exposure to a diversity of role models

MSTE
- Sexual harassment
- Values clarification

Academic Success

Because the MSTE course participants are first-year students who have not declared or been admitted into a major, academic success is a vital goal for them and for the course. More specifically, it is critical for students to achieve a sufficiently high GPA to be admitted into their chosen degree programs. Moreover, for women considering MSTE majors, a strong academic record helps to build confidence and survive the "chilly climate" of male-dominated classrooms. Therefore, in both the fall and spring semesters, the MSTE course focuses on academic success. Academic success topics include academic policies, time management, academic goal setting, academic "reality checks" (i.e., student checks on progress toward goals, calculation of grades and GPA), and university resources.

At the start of the fall semester, students are given a list of their orientation course classmates who are also enrolled in their math and science classes (chemistry, biology, precalculus, calculus). Students are encouraged to contact each other to form study groups, and class discussion addresses ways to make these study groups productive. This year, the students have been registered into common sections of these courses and assigned study groups that meet regularly outside of class. Students also work in these groups on several in-class activities.

Other more in-depth activities are designed to promote critical thinking and address issues specific to women in science majors and careers (e.g., barriers and lack of support). For instance, students complete an inven-

tory of learning styles, and their responses are then used to role-play situations that female students might encounter in introductory science and math courses. In the fall of 2000, the subject-based study groups taught a concept or problem from their subject to their MSTE classmates, addressing many different learning styles. Activities like these affirm that different ways of learning and knowing are valid and help students develop strategies for coping with possible challenges.

MSTE Major/Career Exploration

Many of the classroom activities focus on promoting major and career development. Fall activities encourage students to think broadly about MSTE instead of thinking only about a few popular majors/fields (e.g., computer science, engineering, premed). Students hear from a panel of undergraduate women in various MSTE majors, learn about Holland's career theory, and attend a Majors' Fair with representatives from different colleges at the university. (According to John Holland's theory of career development, there is a strong relationship between personal characteristics and occupational characteristics. The more congruency between the two, the more satisfied the person is in his or her chosen field of work.) To ensure that students see connections, the activities are followed up with structured in-class discussions.

Spring activities focus more on major and career selection. Some activities promote reflection and self-awareness by encouraging exploration of individual interests and personality strengths (i.e., interpretation of the Strong Interest Inventory and the Myers-Briggs Type Indicator). Other activities encourage active involvement by having students interact with visitors from various professional fields and levels of education.

One major/career development activity, the Academic Networking experience, takes place over several weeks. During those weeks, in lieu of attending the MSTE class, students participate in various activities sponsored by other colleges at the university, such as lectures, tours, demonstrations, activities, and social events. One college gives a tour of their state-of-the-art labs and facilities, an overview of the various majors, information about scholarships and internships, and a social time during which students meet other students, faculty, and administrators. Another college provides an overview of programs for one week. The second week, students take field trips to forests, public parks, and other relevant sites.

After the college visits, the students return to the MSTE course where they report their answers to a set of common questions they developed before the visits. Students also discuss their experiences on a computer discussion forum. The combination of advance preparation for the college visits and guided reflection afterward help clarify the students' decision-making processes.

Gender Identity and Decision Making

Women interested in MSTE-related majors or careers often must face traditional views about female roles, including the beliefs that women do not have the skills to be successful in MSTE majors and careers and that MSTE majors/careers are too rigorous or demanding for women. Women can encounter negative attitudes and a lack of support from family, friends, professors, other students, and even internally. Thus, exploring gender-identity issues and debunking stereotypes are central to the success of this group of students. The course explicitly examines these attitudes in several ways. For example, a representative from the university's Equal Opportunity Office runs a workshop on sexual harassment. On other days, students discuss values and their influence in terms of choices and actions, student research on gender in an MSTE career, and relationships as a relevant variable to life decisions.

The two most effective activities, however, are student interactions with female role models and a creative capstone project. Guest speakers, who include upper-class students, faculty, and professionals in MSTE majors and careers, relate their own experiences from the classroom and the world of work and share their coping strategies. By interacting with these knowledgeable successful women, students see that success is possible, and they feel inspired to dedicate themselves to their goals and academic work. As one student wrote: "I was really impressed at [the visitor's] determination to be successful in a male-dominated field with the help of a mentor. It is women like [her] who give young women today the determination and strength to know that they too can do anything they want and be successful at it."

Equally as powerful is a creative, reflective capstone project called "The Amazing Boxes." For this project, students create a box that describes themselves. The boxes include words, objects, and symbols that represent how the students have changed and grown in the first year of college, how they perceive future major and career options, and how the class has helped them make decisions. Students are encouraged to think about being a female while constructing the boxes. After constructing the boxes, students write essays explaining the meaning of the items in their boxes. Instructors also create boxes and share them as a way to generate ideas and share them with students.

During the last two class periods, each student talks about the box she has created. The presentations and the written essay help students bring closure to the year, while the experience of sharing their creative work connects them with other students. The two aspects of the assignment also help students integrate their present

and future personal, academic, and career lives and see themselves and each other as whole persons.

Institutional Responses

Because this course is situated within a first-year experience program, it depends on the MSTE faculty in the university's constituent colleges to volunteer as role models. We have been gratified by the enthusiasm of our guest speakers to make themselves available as sources of information and mentors to our students both in and outside of the classroom. Professors, researchers, administrators, graduate students, and upper-level undergraduates, as well as women working in MSTE fields outside academia were all willing to work with our first-year women.

As an example, the associate dean in the college of engineering was one of our first speakers. She had been one of the first female faculty members in that college and was also one of the first female administrators. Her presence in our classroom had a high impact because she was a groundbreaking role model and because she valued our goals highly enough to take time from her busy schedule. Her visit also expanded the number of faculty and administrators in the college of engineering who were aware of our course.

In this way, we have built bridges to the rest of the university community that benefit our students as they matriculate into their majors. Our involvement with the course has also led to an invitation to join a campus-wide committee dedicated to issues of women in MSTE. The institutional response has been positive thus far, and the network of awareness and support continues to widen.

Future for Women in MSTE Fields

This one-credit MSTE orientation course provides a good example of a program that is designed for women, addresses the classroom/curriculum level, incorporates a variety of innovative learning experiences that use female-friendly pedagogies, and facilitates collaboration across disciplines and units (e.g., intensive, individual counseling; a small, supportive seminar; career and personal development activities; exposure to role models, etc.). This and other innovative efforts should be developed, evaluated, and, as appropriate, replicated.

The curriculum for the MSTE orientation course is flexible. Some of the core components of this program for female students are more easily replicated than others, however. Easiest to replicate are the student self-reflection and the emphasis on collaborative work. It is also vital to establish opportunities for the students to make connections within and outside the university. A course enrolling only female students may be more or less difficult to establish at other institutions. It may be that the MSTE-focused transitions course by itself is sufficient to achieve the program's goals, but we believe that the intensive individual advising is central to reaching these goals. The administrative resources—and large time commitment on the part of the instructor/advisor—may make this component the most difficult to replicate. Other important questions to address are whether the instructor/advisor must be female and what kind of supportive follow-up programs are necessary. That is: Is one year enough to establish the supportive environment and instill the self esteem and survival skills necessary for female students to succeed in these traditionally woman-unfriendly fields?

In conclusion, while women in MSTE majors and careers have made progress, much work remains. Seymour and Hewitt (1997) argue that problems arising from the nature of the undergraduate experience and the culture of the scientific or engineering disciplines (e.g., attitudes and practices of the faculty) at the undergraduate level have a significant impact on whether women and minorities stay in MSTE or switch to other majors. This evidence suggests a need for innovative programs that help women interested in MSTE majors and careers understand and overcome the issues and barriers they face.

Colleges and universities must develop programs that focus on the classroom and curriculum level, incorporate female-friendly pedagogies, consider the total undergraduate experience, encourage collaboration across disciplines and units, and incorporate a rigorous evaluation component. This one-credit orientation course is one example of an innovative program that intentionally incorporates these characteristics. It is a step toward patching the leaky pipeline, and more importantly, toward the higher goal of taking advantage of all available MSTE talent.

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