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## ADJUSTING EDUCATIONAL PRACTICE TO INCREASE FEMALE PERSISTENCE IN THE SCIENCES

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### ABSTRACT

The purpose of this study was to determine the importance of university programs designed to support, encourage, and retain female undergraduates enrolled in math, science, and engineering (MSE) majors. Interviews and roundtable discussions with thirty-two junior and senior female MSE majors revealed numerous factors within the university setting that contributed to female MSE retention and graduation. Four factors are discussed within the scope of this article: support networks and university acclimation, faculty associations, financial assistance, and university support programs that created a more personalized educational experience.

Women in the United States have long been underrepresented in science-related classrooms on college campuses. Recent statistics show that more women are declaring majors in science and engineering fields than in past years, but they are not necessarily graduating from those fields (NSB, 1993). Since the landmark 1972 federal Title IX legislation prohibiting sex discrimination in education, some progress has been made in achieving gender equity in education (see Table 1). Today, women earn more than 50 percent of all bachelors degrees awarded in the United States, a statistic that includes a 9 percent increase in female math, science, and engineering (MSE) majors in the sixteen-year period reported (Table 1). Yet, MSE female graduates still account for only 26.7 percent of college MSE graduates and represent only 16 percent of the science and engineering labor force (NSB, 1995). This statistic indicates a loss of women MSE majors during their college years (Astin, Astin, & Dey, 1992). More recent estimates from the National Center for Educational Statistics (1997) suggest that male to female ratio in undergraduate majors in engineering is still nearly 5 to 1. Moreover, the male to female ratio of engineers in the labor force is 10 to 1.

According to Table 2, 15.1 percent of college females and 26.4 percent of males declare majors in natural science, math, and engineering fields during their freshman year. Women outnumber men in their declaration of majors in the natural sciences (9.4% vs. 6.4%) while men outnumber women in their interest in engineering (19.3% vs. 5%). The declaration of majors in math and computer science is equal for men and women (0.7%). Despite this early enthusiasm for MSE fields, only 8.9 percent of the MSE-graduates are female graduates with MSE degrees versus 32.9 percent of their male counterparts.

Table 2 shows a positive trend among men to join the MSE ranks in the areas of math, computer science, and the natural sciences. Female student attrition, in contrast, occurs in all fields except math and computer science. There is a significant increase (and possible migration to) the social science and behavioral fields for both men and women, and attrition is substantial for both sexes in the field of engineering. Not indicated in the table is the parity women are approaching in a few of the natural science fields: women received 49 percent of the bachelor's degrees in the biological sciences and 32 percent of the bachelor's degrees in the physical sciences (NSB, 1995). However, according to these statistics, women are underrepresented in comparison to their male counterparts in all areas of science and engineering by graduation (Rayman & Brett, 1995).

The problem of MSE attrition faces both men and women and is a phenomenon that occurs across the nation's higher education institutions (NSB, 1993). Students studying in MSE fields are not always prepared for the grueling curriculum that

Table 1. Distribution of Bachelor's Degrees in MSE by Sex (NSB, 1995)

	1975	1991	Change
Males	82%	73.3%	-8.7%
Females	18%	26.7%	+8.7%

Table 2. Percentages of Declared Majors (Freshman Year), Graduation Rates (NSB, 1993)

	Declared		Graduated	
	Female	Male	Female	Male
Natural Science	9.4%	6.4%	4.8%	12.8%
Math/Computer Science	0.7%	0.7%	2.4%	7.9%
Engineering	5.0%	19.3%	1.7%	12.2%
Social Sciences	10.0%	4.9%	15.9%	33.4%

includes numerous no credit labs and usually takes a minimum of five years to complete (Hyde, 1997). The mere fact, however, that women experience a differential decline in academic and career aspirations in scientific fields during their college years (Sadker & Sadker, 1990) combined with lower persistence rates for women than men in MSE disciplines (Strenta, Elliott, Matier, Scott, & Adair, 1993) suggests that possible gender inequities exist within MSE cultures.

### RESEARCH QUESTIONS

While many researchers have examined the issue of female science attrition during the precollege experience (Alper, 1993; Kahle & Lakes, 1983; Pallas & Alexander, 1983; Sadker & Sadker, 1985; Tobin & Gallagher, 1987; Vockell & Lobonc, 1981), only a few gender studies have focused on retention at the college level. The literature concerning science education at the college level has concentrated on the reasons why women have not succeeded in science programs and with an emphasis on observed disparities in classroom interaction. Yet the reasons some women do succeed and graduate in MSE have not been explored. Understanding the success factors in educating females in MSE can make an important contribution to the retention of female MSE majors.

The present study focuses on college persistence and female graduation in MSE programs and looks to specifically understand the importance of university programs and the institutional context associated with female MSE persistence. What characterized the experience of the women who stayed in science and graduated successfully? What type of interactions and events impacted their decision to persist? What types of relationships were meaningful to their experience, and did those associations help them to persist in their academic pursuits? What was the nature of their context? Did the university's special programs for female MES students make a difference in female science persistence?

### PARTICIPANTS AND UNIVERSITY CONTEXT

Our research was conducted at a western research university and drew participants from a university funded program called Project Access. The goal of Project Access was to combat female science attrition by offering a community of support in a gender-neutral environment. Starting in 1991, each year Project Access recruits twenty top female students from across the country during their senior year in high school and brought them to campus for an eight-week summer workshop, held prior to the participants' freshman year.

The program provided these young female science students with a \$2000 scholarship during that first year. Additional assistance was offered throughout their remaining college education including scholarships, cohort groupings, seminars, lab research, mentors, help-session, and support groups—all in an effort to encourage graduation in an intended MSE field of study. The objective of the

program was to acclimate the female students to college life and introduce a support network of concerned professors, counselors, and staff in an effort to recruit more women to the science and engineering ranks.

During the summer workshop a different subject was taught each week by a professor from one of the various science departments. The main purpose of the summer program, however, was not the expansion of scientific knowledge but the development of beneficial relationships. According to Dr. Jones, the program director,

The main purpose of the program is to enhance the participants' experience in science and the best thing we can do for the women is foster long-term relationships that will benefit the students during their freshman year, particularly when class sizes are large. We also try and provide as many connections as we can with the right people and the right places. (Interview, January 1997)

The program, developed at the university in 1991, was initially funded by the National Science Foundation. The university now funds the program as part of its commitment to policies of nondiscrimination and affirmative action in all aspects of education. At the time of this study, the program was administered through the office of the dean of the College of Science, who devoted considerable amounts of time and money to insure its success. As of 1997, the program has involved just over 120 students.

Interviewing Project Access juniors and seniors allowed us access to females who had demonstrated science proficiency and ability and who were presumably determined to graduate in an MSE field. These participants also helped us better understand the university MSE experience and the role of formal university programs such as Project Access on MSE retention and attrition.

### DATA COLLECTION AND ANALYSIS

The problem of female science attrition has traditionally been studied using quantitative procedures. By providing statistical evidence for factors contributing to female science attrition, the problem has been substantiated but the causal linkage remains unclear. Positivistic methods have not provided us with the details of social occurrences that could reveal more specific explanation of the phenomenon of persistence. As Miles and Huberman discuss, "With qualitative data one can preserve the chronological flow, see precisely which events led to which consequences, and derive fruitful explanations" (1994, p. 1).

Since teaching occurs within a social and cultural environment, we adopted an interpretive methodology in order to provide a substantive focus on human meaning and social interaction. Symbolic interactionism was used as the theoretical framework to understand the day-to-day interactions of the participants within the MSE program (Erickson, 1986). Derived from the work

of G. H. Mead, the theory's emphasis is on the self, and the construction of meaning through interactions which are then interpreted by the individual. Symbolic interactionism allows discovery of "personal secrets" and strongly held beliefs by actors that are constructed within specific cultures and environments and among groups of people who influence and are influenced by structures (Woods, 1994). Symbolic interactionism requires the study of people in their natural settings and interpretation of their actions in order to formulate what the actors are doing. In particular, we sought to examine the impact of university factors on female MSE students. Use of symbolic interactionism allowed flexibility in determining how female science students made sense of and contended with institutional structures, conflicts, hierarchies, and practices. Through documentation of details of specific behaviors and practices, we gained insight into beneficial aspects of university programs that assist female students in MSE persistence.

Data collection included aspects of both qualitative and quantitative research methods and was conducted during three phases. First, we researched the features of Project Access. Key people involved in the development and organization of the Access program were interviewed, including the dean, the director, professional staff member, and professors. We attended numerous Access meetings and met with various departments to understand the day-to-day operation and function of the program. Biographical and curricular data on all the students who had been involved with Project Access during its six-year existence were obtained and analyzed to elicit demographic patterns. Descriptive statistics were used to analyze the data in order to determine statistical averages and means of student GPAs, number of majors declared, specific field chosen, and academic year of graduation or attrition.

During the second phase of the study we spent over two months investigating the personal and academic relationships of the thirty-two junior and senior Project Access students that remained at the university and who were willing and available to meet (twenty-two Project Access students were accepted as freshmen in 1991, followed by 21 students in 1992 to equal a total of 43). At the time of this study (1995-96), seventeen of these students were juniors, twelve seniors, and three had graduated. Eleven of these original students had discontinued their education at the western institution; some to attend another institution, others to temporarily postpone their university studies. Semistructured interviews allowed us to gain information about the participants' background, their experience in science classrooms and with the Access program, their personal relationships and sources of influence, as well as their advice for future female science students.

In the process of gaining understanding of the participants' experience, we urged the women to speak candidly and reflect on the details relating to their life, with particular attention to their college career (see Appendix for sample questions). Operating from the symbolic interactionism research framework, we desired to understand the day-to-day interactions and events that affected their

decision to persist and the personal and academic relationships that were meaningful to their academic pursuits. Friends and family of the participants were also interviewed in order to gain further insight into the personal and academic lives of these women. In gaining understanding of our participants' experience, we wanted to reveal important relationships and the role of the university.

Using the semistructured interview method allowed us to collect detailed information on specific cases, which we needed in order to perform adequate case analysis and cross-case comparison analysis. We tape recorded the interviews and transcribed our field notes verbatim within forty-eight hours from the time of the interview in order to create a trustworthy database that we could revisit. The interview data were classified and coded by identifying themes and categories that represented similarities and differences within the cases. A cross-case analysis of the interview data allowed us to devise categories and subcategories that assisted in the refinement of an achievement analysis of the participants.

During the third phase, the informants participated in a roundtable session to discuss their experience as females in MSE undergraduate programs as well as their experience with the Project Access program. The preliminary results of our study were discussed with the participants at this time, allowing us to further our understanding of their experience as well as creating a forum where participants were free to evaluate and discuss the findings of the research. The roundtable was a critical element in obtaining confirming or disconfirming evidence of the evolving hypotheses and conclusions and helped clarify the impact and importance of each individual factor.

To ensure that the study offered a high degree of internal validity, we allowed the specific forms of my instrumentation to be developed on site. They emerged while in the process of doing the field work and as the need arose for new methods of data gathering presented themselves (Spindler & Spindler, 1992). Also, we triangulated our research methods by performing semistructured interviews and then by including the participants in the roundtable discussion where we as a group determined the final analysis (Miles & Huberman, 1994). The use of multiple indicators, such as the interviews conducted with professors, administrators, family members, etc., also provided an additional validity check.

## RESULTS

Our interviews of the thirty-two Project Access students revealed a pattern of personalities and behaviors that was consistent among the successful female science participants. From their biographical data, the sample group was found to be academically successful and achievement oriented. Their combined scores averaged to a high school GPA of 3.9, 29 on the ACT, and a college GPA of 3.4. Over the two-year period that our study was conducted, 78 percent of the participants persisted in obtaining a MSE degree and 25 percent of the sample

intended on enrolling in graduate school, a significant increase over the national sample.

Phases two and three of the research uncovered numerous factors within the university setting that had significant bearing on the participants' decision to persist in MSE majors. The research indicated four aspects within the university and school environment that made a substantial difference in the education of the women investigated: support networks and university acclimation, faculty associations, financial assistance, and university support programs.

### Support Networks and University Acclimation

The Project Access program was unanimously lauded by the study participants as having a significant impact and being a key factor in their MSE persistence. Specifically, the participants overwhelmingly agreed that the most beneficial aspect of the program was the important relationships they developed while in the program. According to Nancy, Access helped her to form a study group.

It really helped to get into the math classes and already know other girls in the class and have someone to study with for the first couple of years. Because there will be maybe two girls in the whole class, out of 15 or 20, I mean you could feel like you're all alone. But we get together and study and we're all in sciences and it was nice to have some friends.

Robyn added, "I think that having study groups with friends was probably the most valuable part about the Access program. I've kept a lot of those relationships. It's really nice when you're in a class struggling that you have some other people to help you out." Julie agreed:

At the beginning we were all basically in the same classes together, so we had each other to study with and then we'd just have so much fun together. And just bumming around. It was how we'd vent our feelings about physics and organic chemistry. If they hate it and I hate it and we all get together, it's a pretty dynamic conversation. You need some kind of release, some kind of an outlet. It was good to know that they were struggling with it too.

The participants needed a support system that they could rely on, not only for study but also to talk and have fun—someone who could relate to their situation and sympathize with their trials. Karen also acknowledged the importance of friendships:

The best thing I can say about Access is the fact that when everybody started school fall quarter that first year, we already had 21 friends. And many of them, actually four of them, are still my best friends even till today. It was very very scary, especially coming from a small town, and science is very intimidating. A support group. That was very important, I couldn't stress it enough. Because even though we weren't necessarily all the same major, those first 2 years, there was always an Access girl in one of my classes or I



would bump into them on campus. Always. We would study together and it even helped having someone to sit next to in class.

Throughout the eight-week summer seminar the women lived together in the dorms, a critical element of the program that has since lost its funding. Ronny explained,

The fact that we were thrown together for many hours of the day, we had to become friends. I mean, a lot of the bringing together and stuff could have even been the fact that we all lived in the dorms. And we lived on the same floor. So for the entire summer, we saw the same people.

Betty agreed: "I think that was an important factor also because we spent a lot of time together." In fact, many of the girls chose to room together following the summer quarter. Jane explained, "Actually I lived with four other girls from the Access program during my first year. So that was nice to have roommates in a lot of the same classes." Summer added,

I think living on campus was very helpful, I actually. Because, I've lived both off-campus, at my home, and on-campus. And I've found that I tend to study a lot more if I'm on campus. The resources are a lot closer for that. I just think the student atmosphere helps a lot.

Andrea noted the value of a built-in study group,

I lived in the dorms up here my first year in college. That was nice because we were able to get together and study until 5 o'clock in the morning if we needed to. And I had a lot of classes with them, especially having friends in the Access program.

The Access program also assisted the participants in the acclimatization process. Dr. Jones explained,

It is common for freshmen to experience some anxiety stemming from their new environment and the new culture they are thrown into. So we try to familiarize the students during the summer quarter with their new environment and the various services that are available to them.

Bev noted, "I think the summer session helped me to get over my fear of college because I was really afraid that I was going to come from high school and not do well in college. They showed us where everything was and who to turn to when we needed help." Bernice agreed: "We got to know the campus and actually we felt comfortable up here before we actually had a full load of classes." Mindy concurred, "And in terms of different resources on campus. Like where all the computers are that students actually have access to for doing a lot of the math, you know, using a spreadsheet, or graphs, that was really helpful to learn about so early."



Although few of the participants commented on the benefit of added knowledge, most of them were grateful for the new skills relating to the production of technical reports that they were taught during the summer seminar. Joni noted,

The technical report helped a lot in writing my chemistry lab reports. My reports were wonderful compared to students that didn't know what they were doing to begin with. So I walked in with a little more confidence, at least knowing how to put them together.

Lorna agreed: "We learned a lot of valuable skills. They had us do a lot of spreadsheet, data manipulation, and so forth. And that was helpful in the science classes to follow." Lori remarked, "The Access program helped me because I didn't know anything about computers. I had had a couple of computer courses but that is it. I didn't know anything about writing lab reports or anything, so they taught us a lot of things."

The stories from the participants resembled one another, but each participant had her own perspective and view of the importance of the development of a support network. Consistent throughout the stories told was the implicit fear of the freshman year. Reflected in the delivery of their tale was a bit of trepidation and a sense of being overwhelmed by the "intimidating" professors and the "rigorous" science courses—not to mention the large class sizes typical of the freshman year. Mary explained her thoughts about her freshman year:

It was really good that first summer to be prepared for a tough year and to have friends to talk to. You run into a lot of your hard classes as a freshman. That's when everybody started taking the physics series, and you start butting your head up against the wall with organic chemistry and thinking, "Why am I doing this?" You're not doing as well as you did before in classes and you're thinking "Why am I doing this? I'm not doing as well. This sucks. I hate studying until one o'clock in the morning every night and pulling Bs." It's frustrating.

### Faculty Associations

Associations were encouraged not only among the participants but also with professors, administrators, school counselors, and student service representatives as well. The professors involved with Access were an important feature of the program. Their association gave the participants an added boost of self-esteem in their ability to accomplish their goal. Judy conceded, "Access definitely helped me to succeed because it gave me some confidence. It also gave me professors that I knew, like Dr. Rudy. And that's definitely always a help." Ricky said, "I think what it was that they [Access professors] expected a lot, so we kind of had to fulfill their expectations and it kind of gave me a confidence that I could do it."

The professors involved with the program were willing to engage themselves with the students and were willing to take extra time in assisting them. Michelle

agreed: "I think the biggest support for me came from the fact that there were professors and teachers that were interested in my success. That really impressed me and gave me confidence that I could do it." Their association with administrators in high places also privileged the participants. As Summer recounts,

It [Access] definitely gave a lot of the girls a strong foundation just because of the support system from the professors and administrators; you know, you're basically on a one-on-one with the dean of science, so if you have any problems you know that you can go to him.

The Access program advisors encouraged the participants to develop relationships with professors and to not be intimidated by their teachers. Lori noted, "They [Access administrators] taught me to not be afraid to go talk to a professor one-on-one. That's a big one. They would always tell you, 'Just go talk to them,' or, 'Tell them who you are,' or 'Hang around a lot.'"

Rapport between students and faculty was an important factor that affected the participants' persistence. On numerous occasions stories were told about various professors who made a difference. Bev attributed a professor's encouragement as a factor in her decision to persist: "Dr. Jones was there when I was ready to give up. He convinced me I could do it and that I was as smart as everyone else. He worked with me the entire quarter to help me get through calculus." Betty went into more detail with her praise for a professor:

I took genetics from Dr. Randal. Excellent professor. And he offered me a job because I did well in his class. And I decided to accept his offer even though at that time I wasn't sure what field I wanted to be in. I'd heard a lot about him, that he was just really great to work with. I liked him as a professor; you learned a lot from him. He's just somebody who is really comfortable to be around. And I've gone back and gotten a lot of letters of recommendation from him. He's a nice guy. He always remembers us. He really cares about you staying in science if that's what you want to do.

The data suggest that a key strategy of success used by the women was the conscious effort they made to get to know their professors. The majority of the participants were unyielding in their commitment to succeed in their courses, and would often risk rejection in order to develop a relationship with the individual they knew that could offer them assistance. As Mary explained, "I think it's important for students to get to know their teachers. I always liked the professors that would make themselves available, and who were willing to work through the problems with you in their office. I always did better in their courses." Nancy adds,

I had this intimidating professor for honors chemistry the first quarter and I thought, "I can not handle this class. I can not do this." The material at one point was so foggy and so fuzzy that I had nothing else to do but go into his office and say, "I need help. I just don't get it." And he was very helpful. So

as a freshman I just kind of learned they're [professors] not as scary once you get in there.

It was common for the students to develop personal relationships with a particular professor for whom they had a preference. Barbie related her experience:

I worked with a professor on his research that he was doing and then since that, he kind of took me under his wing to make sure I'm taking the classes that would be good for what I want to do. And he's always checking to make sure I am surviving. And too, he would suggest what classes and what teachers to take, and that really made a difference.

These stories of positive associations with professors were not unique. Similar stories were told by the other participants, further evidence of the significance of the relationship. The results of these relationships were beneficial; often the professors became mentors, enabling them to positively influence the outcome of the Access students' decision to persist. According to the data, professors who offered encouragement had an enormous impact during critical turning points of the participants' academic careers.

### Financial Assistance

Another benefit that Access provided was financial assistance during the participants' freshman year. The \$2000 scholarship enabled the students to concentrate on their academic work rather than on outside work. Rhonda commented,

It was rewarding to sit there on the first day of class and get a big check and for them to put us up in the dorms and to meet a lot of people; just to be able to spend your time just devoting yourself to your studies was great.

Barbie explained the personal significance of the Access scholarship, "And the \$2000 has helped a lot. I don't think I would have been able to do it, because of my family background, if it weren't for the fact that I had these scholarships." Bernice summed it up: "Well, if there wasn't the scholarships to begin with, nothing else would have been. The bottom line, scholarships have paid my whole way through, completely. I wouldn't have been able to do anything without them."

Scholarship money was especially crucial to the 25 percent who were married and who might otherwise have been expected to quit school to support their husband's academic pursuits. Judy explained, "I have applied for every scholarship I can qualify for. I've even changed majors to fit the description because being married has placed an additional strain on our finances and we don't have the money to pay for my schooling as well as my husband's."

Scholarships contributed immensely to the persistence and continuation of the women participants in MSE fields. Scholarships like the Hughes biology award and the Access program received rave reviews. The students were aware of and

grateful for the benefits they had received from such programs and credited the funding as critical to their continuation and obtainment of a MSE degree.

### University Support Programs

Other programs on campus also contributed to female MSE student persistence. With a university emphasis on research, there were many avenues set-up to support students' academic scholarship. Programs sponsored through the various departments or by student services received credit for lending support to the participants at critical points during their academic careers. For example, when one participant, Karen, desperately needed a job, a campus organization called UROP (Undergraduate Research Opportunities Program) came to the rescue.

I just about had to quit school because I couldn't keep my [off campus] job and survive my class load. But then I heard that UROP hired students to work with faculty on their research. It had a list of professors who would be willing to take on students, and they used their own funding to pay me. It worked out really well.

Another support agency provided by student services that received a favorable review was the Women's Resource Center. A Project Access sponsored workshop made the women aware of the center's resources if they were needed during their college career. In fact, a number of the participants turned to the center during trying times including serious illnesses and cases of sexual harassment. Lori explained:

During the second quarter of school I was having some serious medical problems and they were exacerbated by the stress of my classes. My professors were going to fail me because they didn't really believe that I was sick. It was lucky that I knew the director of the Women's Resource Center because I called her and said, "This is the deal. You know me, you know I'm not faking." So she called all my professors and took care of everything, because I was so sick, I couldn't even do it. And it was such a big help that I didn't have to dig myself out of a failed quarter. And they would help me network with other people. They would say, "Oh well, I know this person at this office." And "You need to write this letter." They'd tell me exactly what I needed to do so that I didn't forfeit all my scholarships.

The director of the advising center on campus was also mentioned on numerous occasions as a contributing factor to the Access participants' persistence. During a discussion about how Michelle decided to become an engineer, she explained,

I went and talked to Joni Smith, she was the freshman advisor. And I said, "Well, what is the difference between a chemist and a chemical engineer?"

She said, "The money, so go for it." And that's why I started, just because she said that. And because she was really nice and she had the confidence in me.

Like Michelle and Karen, many of the participants received advice on career choices and lab research opportunities, as well as advice on available mentoring and tutoring programs that turned out to be significant to their career development.

A final program that deserves recognition is Minorities in Engineering, a program developed to foster the involvement of minorities and women in engineering disciplines. To do so, the program provided tutoring, free of charge, as well as assistance in class scheduling and stress management. It offered weekly seminars that discussed topics of interest to women and minorities and assigned a mentor to every participant. It was this program that assisted Jane in her engineering endeavors.

I wasn't making it in engineering. It was too tough and I was ready to give it up when I heard that the Minorities in Engineering Program provided assistance. So I enrolled and it literally saved me. I received hours of free tutoring and explanations, as well as a lot of encouragement and unconditional support. I give them all the credit for my survival.

#### KEY FINDINGS

The results of this study highlight the necessity for the development of a firm support system that can be relied on throughout the female undergraduate experience. Most participants agreed that they were fortunate to be involved with the Access program, particularly because of the support it provided and the associations they developed. For these participants, the Access program introduced them to numerous sources of assistance. Prior to their freshman year, a year described as lonely and rigorous when attrition is particularly high (Alper, 1993), the students were assimilated, nurtured, and encouraged to develop important relationships with their peers, professors, and administrators. The development of these positive associations added to their ability to collaborate as a community of learners, sustained them throughout their college experience, and often led to further opportunities in their field.

The data also suggest that the participants reacted positively toward any curriculum or program that enhanced their ability to establish mutual association with professors, female friends, advisors, study partners, mentors, cohorts, administrators, or other beneficial relationships. The rigorous curriculum and academic challenge they faced motivated the women to seek positive influences for support. The participants were grateful to professors who required study groups and to other programs, like the women's center and Access, that helped them organize cohorts and e-mail networks. Their endurance and persistence often depended on the network and the proximal relationships they developed.

To further the personalization process, this study emphasizes the importance of the student-professor relationship. Those professors, male or female, willing to devote their time to the development and enhancement of the student beyond the classroom setting were critical to the success of the female participants. This research suggests that professorial associations are one of the most beneficial proximal relationships a student can enjoy. The consequences of the association included emotional support, knowledge enhancement, added confidence, letters of recommendation, encouragement, and other support. In return for the time spent mentoring students and building a relationship with them, the professor earned the respect of the students, the position of mentor, and the credit for fostering future graduates from their field of inquiry.

The cultivation of relationships with other female friends as well as professors and advisors was another critical benefit of the program. The Access program provided meaningful interactions at the beginning of the academic career with fellow students and peers. For many of the participants the Project Access peers were the basis of their network and fortified their support foundation by furthering association with others. For those who succeeded, this initial support network was critical to their program persistence.

The case informants were also in agreement about the added benefit of being awarded scholarship funds. The money was critical to the participants' continuation, often because of conflicting demands caused by marital status or lack of family income. Scholarships were also very valuable to those whose only source of outside income was off-campus work.

As determined by this research, factors within the university environment were important to the persistence of the female participants. The group in this study benefited from the cohort involvement, faculty association, scholarships, and informal study groups that evolved out of their participation with the Access program. Finally, positive outcomes were produced through the students' involvement in the well-coordinated university programs in which advisors, professional staff, and professors were encouraged (and paid) to be available and to assist and mentor female students.

## DISCUSSION

Recent research on retention has found similar factors determined by this study to be significant to persistence. Seymour (1992) found evidence that persisters make use of situational resources. Vazquez-Abad, Winer, and Derome's (1997) study on physics persistence recommended universities provide additional support and re-structure programs to accommodate students' needs. Findings from Mallette and Cabrera (1991) advocated the development of programs that focused on increasing academic ability, faculty interactions including peer-mentoring programs, as well as considerations for student finances in order to discourage attrition from higher education institutions. Rayman and Brett

(1995) positively correlated cohort involvement and good advisement from faculty and staff to persistence.

In an extensive review of the literature, Tinto (1975) developed a theoretical model that sought to explain post-secondary education dropout. He concluded that attrition was due to insufficient integration into the social sphere and the academic domain. In 1987, Tinto expanded his research on college dropout to include retention factors, which resulted in a student integration model of college persistence. According to Tinto (1987), interactions between the individual and the academic environment (faculty and staff), as well as social interactions between the student and peer groups within the institution, strengthened the integration of that student which resulted in the students' ability and desire to persist. His seminal research supports the findings of this research in that attrition can be deterred by enhancing the social and academic interactions and through affiliation with peers as well as professors integration into the prevailing value system of the college collectivity can increase persistence.

Researchers interested in the female college experience, in particular, have identified many of the same factors discussed by the participants in this study as significant. Sadker and Sadker (1985) revealed the benefits male students have long enjoyed from professorial attention and association. The Wellesley Report (Rayman & Brett, 1993) emphasized the need for the establishment of mentoring programs and role models. The importance and value of study groups, cohorts, and group collaboration, particularly for women, has also been previously discussed in the literature (Goldberger, Tarule, Clinchy, & Belenky, 1996). The results from this study suggest that there may be underlying significance in the value of these contributing factors that are particular to women.

A theme that emerged from this investigation was the apparent reward system that motivated the participants to persist. The participants in this study often credited extrinsic factors for their success and often referenced the need for external validation and support, which in turn built their confidence, thus enabling them to persist. Even though, according to Hewitt and Seymour (1991), external validation is not a common practice within university settings, the reputation that came from being involved with the university's elite Project Access program was an external reward that motivated the participants to persist.

Initially, the Access program was an external validation of the participant's personal worth and academic ability. This recognition was important to the participants, particularly during the first year. The Access program offered an important support element that was critical to the participants' persistence. This study noted that the positive associations developed through Access gave the participants an added boost of confidence in their ability to accomplish their goal. Other contributing factors to the success of many of these participants was the carrot on the end of the stick—a career upon completion—as well as the scholarship money that they received, both external rewards. In contrast, traditional cognitive approaches to teaching benefit male students, where



independent exploration is encouraged, and there is no external reward for the individual except for the delight of mastery (McIlwee & Robinson, 1992). Science curricula and pedagogy typically rely on intrinsic forces within the learner, a situation that may inhibit female MSE majors chances of success.

Research on socialization patterns has revealed that females are socialized toward an affective orientation and are encouraged to develop attitudes of nurturance, sensitivity, physical attractiveness, and emotional expression (McIlwee & Robinson, 1992). Research that indicates that women are socialized to be more compliant and less aggressive than men usually attribute female success to extrinsic factors (Rayman & Brett, 1993). This pattern of socialization is particularly harmful to females who desire to study in science-related fields because they are less likely to be validated by a reward system that favors male patterns of behavior.

Research by Ethington (1995) confirmed that socialized self-concepts discussed above have a negative influence on females and often penalize women more than men. Ethington's study (1995) credited female success in college science courses to a positive self-image and extrinsic attributes that sustained the participants through the times when they began to question themselves and their abilities.

The cultural perspectives and theories relating to socialization patterns of females confirm the results identified by this study. The research suggests that female learners have distinctly feminine needs when it comes to MSE education. In contrast to traditional educational approaches, this research ascertains that in order to increase persistence, female MSE students may need more external rewards as well as more assisted opportunities to develop personal relationships with fellow students and professors. Integration into the social and academic environment was an identifiable factor that contributed to their persistence and their completion of a MSE degree.

### CONCLUSIONS AND IMPLICATIONS FOR PRACTICE

An achievement analysis of the data presented indicates that factors within the university context, including institutional factors, play an important role in female students' pursuit of a science-related degree. Researchers acknowledge that major losses of female MSE students occur at the college level, particularly during the freshman year (Alper, 1993). Recognizing the college years as a crucial juncture in a woman's decision-making process, Ehrhart and Sandler (1987) argue that higher education is in a "unique position to facilitate and encourage women's involvement in mathematics, science, law, and business because they educate future professionals in these fields and serve as gatekeepers to the professions" (p. 2). Researchers claim that postsecondary institutions can offset the decline in female science enrollment by insuring opportunities for women and providing special programs to facilitate women's

entry into traditionally male programs, as well as by encouraging the recruitment of women to these programs (Ehrhart & Sandler, 1987; Tobias, 1990).

This study focused on the aspects within the culture of education and the proximal relationships that are key to female achievement of a MSE degree. In order to target our recommendations to the education community, we focused on the factors within the institutional environment with the emphasis directed toward the beneficial factors that positively influenced female science education. Our analysis highlights the needs of women and their desire for a more supportive and involved educational experience. Understanding the process and significant factors related to a female's education is valuable information for those interested in the retention of the female MSE population. According to this study, early intervention and encouragement can make the difference.

Adapting educational processes to include more programs that offer support and encouragement for females is recommended. Programs where women are afforded the opportunity to build a network of associations that will strengthen their desire to persist would result in a more equal education for women throughout their university experience. Thus, of critical concern to educators should be the advancement of positive associations and support networks within the university setting in order to help female undergraduates pursue a more personalized and inter-connected educational experience.

Universities need to assist professors in the development of personal associations with students and train them in effective ways of mentoring. Recognition for involvement and enthusiasm toward the enhancement of essential relationships would be a positive motivation for faculty who are reluctant to give of themselves outside the classroom. Educational administrators should encourage professors to lengthen their office hours, soften their approaches (to lessen the intimidation factor), and become interested partners in the educational process.

Continuation and enhancement of e-mail support networks, cohort assignment, mentoring programs, or any cost-effective program which furthers the opportunity and availability of favorable interactions and support for women interested in science are recommended. Programs that provide information to faculty on effective methods of fostering student study groups and cohorts would be advantageous. When funding is available, assigning a dedicated faculty member the responsibility of advising and encouraging women to obtain their science degrees and acting as facilitator for a cohort would be worthwhile. Grant money from the National Science Foundation should be sought after to develop and fund programs like Project Access. Any program that encourages women to obtain their science degrees through the development of a support system within the university setting is advocated. While these suggestions appear critical in the retention of females in MSE, they may be equally valuable in retaining male students since the attrition of both male and female MSE majors needs to be eradicated.

APPENDIX A  
Sample Interview Questions

Can you give me a brief overview of your academic history and what brought about your interest in science?

What year did you enroll in the University of Utah and what year are you in now?

What year do you intend on graduating?

What specific field do expect to graduate from?

What type of career, if any, do you Plan on pursuing?

Why did you choose to major in science, engineering, or math?

Have you ever changed your major during your college career?

What is it that you like about the science, engineering, or math?

What do like best about the science, engineering, or math courses you have taken in college?

What do like least about the science, engineering, or math courses you have taken in college?

Do you believe that your experience in science would be any different if you were male instead of female?

How have your professors influenced you?

What has been the predominant influence on your decision to pursue a scientific degree?

What factors have helped you the most to remain in science?

Have you relied on any kind of support system to help you remain in science?

What are the contributing factors that have helped you to remain in the science fields?

What is it that has helped you to be successful in your science-related studies?

What challenges have you faced while pursuing your science degree and how have you overcome them?

What could the University do to offer more assistance to female students majoring in science, engineering, or math fields?

What suggestions would you give to a future female college student interested in majoring in a science-related field?

#### Additional Sample Interview Questions for Semi-Structured Interview of Access Students

How helpful have you found Project Access in supporting your academic goals in your science, engineering, or math field?

Has Project Access made a difference in your continued pursuit of a science, engineering, or math degree? Please explain.

What aspect of Project Access have you found to be particularly helpful?

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